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BROADCASTING AND TELEVISION

IN the past ten years the number of television licences in Britain has grown from less than 15,000 to nearly eight million, and the estimated number of adults aged sixteen or more in homes with television sets from 80,000 (all in the London region), which was 0·2 per cent of the total adults, to 21,850,000 or 57·9 per cent. For every person who had a television set in 1947 there are five hundred to-day, and six out of ten adults can see television in their own homes. An admirable broadsheet issued by Political and Economic Planning* sets out some of the facts behind this remarkable expansion, the characteristics of the television public and the development of commercial television and of public attitudes towards it. It attempts no critical judgments, but indicates some of the problems that accompany this rapid entry of television into the lives of millions of people, and more especially it gives a broad picture of the position of television in the economic life of the community in Britain.

Experiments in television broadcasting began in Britain in the autumn of 1929, and the world's first public television service was started by the British Broadcasting Corporation from Alexandra Palace in November 1936. When the service was closed down at the outbreak of war in 1939, there were still little more than 20,000 television receivers in Britain, and although the service was re-opened in June 1946, until 1949 it covered only the London area, and in March 1949 there were still only 127,000 licence holders. The eighteen B.B.C. transmitters now in operation cover about 98 per cent of the population, while 75 per cent are covered by the six transmitters of the Independent Television Authority, and this will be increased to 85 per cent with the opening of the Central Southern and North-East England stations later this year. By 1959–60, the Independent Television Authority hopes to have eleven stations in operation, covering about 90 per cent of the population.

Most of the television sets now in use in Britain have 14-in. or 17-in. tubes; but although screens are very much larger than they were ten years ago, the average size of a set is still smaller than in the United States. Retail sales of television receivers in Britain are estimated at 1,439,000 in 1957 at an average price of £75 18*s.*, including purchase tax at 60 per cent, and about 50 per cent of retail sales during the past two years have been by hire purchase or credit transactions. Rented sets may possibly exceed half a million, and the number of new subscribers to television relay services in 1957 is put at more than 80,000.

The United Kingdom now ranks third with Canada in its ratio of persons to television receivers (6); only the United States (4) and Hawaii (5) exceed it. For Europe, Monaco (10), Belgium (45), Denmark (45), West Germany (55), Netherlands (56), U.S.S.R. (67), France (72) and Italy (78) are the only countries having ratios of less than 100. There are more television receivers in operation in the United Kingdom than in any other country except the United States, and with 55 hr. of weekly transmission the United Kingdom has double the hours of viewing of any other European country except Italy (45), France (41), Poland (39), Spain (32) and the U.S.S.R. (32), though far exceeded by the United States (133) and Canada (91). There are now more people in Britain with licences for television than for sound alone, and since 1953 the number of television licence holders has been increasing by 1·2 million each year; it is estimated that in February 1957, 36 per cent of all adults were able to receive both B.B.C. and I.T.V. transmission in their homes, and another 23 per cent B.B.C. transmission only.

The nature, as well as the size and geographical distribution of the television public, have been steadily changing since the Second World War; and while, ten years ago, in terms of social class, the upper 12 per cent had nearly half the total number of sets in use and the bottom 68 per cent only a quarter of the total, there is now little to distinguish the television public from a representative cross-section of the public in this respect, namely, one-quarter middle class and three-quarters working-class. There is also probably little to distinguish the television public from a cross-section of the public in respect of occupation and education. Households with television, however, are on average larger than those without. During the last quarter of 1957 the average evening sound audience of 3,650,000 was less than half as great as the average evening television audience of 7,400,000.

To judge of the effect of the contents of television programmes on the public would require a much more searching inquiry than P.E.P. has attempted for this broadsheet, but the comparison between the programmes of the Independent Television Authority and the British Broadcasting Corporation presents some indication that the latter has regained some ground lost initially. Nor is the effect of advertising clearer, though the growth of television advertising expenditure from some £2 million in the last quarter of 1955 to nearly £32 million in 1957 is noteworthy and is estimated at about 11 per cent of all advertising expenditure, compared with 4·5 per cent in 1956. Primarily such advertising is concerned with mass-market goods, for which the unit of purchase is small. The broadsheet concludes, however, that it is impossible to say to what extent the Press has suffered from the competition of television advertising, because the slackening in the rate of growth of total Press advertising revenues may be due to many factors unconnected with television.

* *Planning*, Vol. 24, No. 420 (24 March, 1958): Television in Britain. Pp. 37–68. (London: Political and Economic Planning, 1958.) 3*s.* 6*d.*

The magnitude of the economic impact of television is well summarized in the concluding section of the broadsheet. Of consumer expenditure on the provision and maintenance of television receivers, excluding licence fees, estimated at about £150 million in 1957, £109 million represents the purchase of new television receivers; £25 million the servicing of existing sets; aerials, tables, etc., £6 million; and rented sets, £12·5 million. The cost of licences to the consumer amounted to about £18 million, including £2 out of the £3 combined receiving licence which is allotted to television and an allowance for the £1 excise duty payable for only part of the year. The total £170 million is the equivalent of less than 1·3 per cent of all consumer expenditure at market prices. Television advertising expenditure, from which the independent television service is financed, approached £40 million, including production costs, and the Exchequer revenue from purchase tax on television receivers was perhaps £31·5 million. The £1 excise duty payable on television licences will yield £8 million or more in a full year, and in 1957 the Exchequer received about £15 million from the B.B.C. licence revenue.

Nevertheless, while it could be questioned whether Great Britain can afford to put into television capital expenditure of the magnitude of the post-war years, having regard to other demands for capital development, notably in transport and roads, the economic impact may well be insignificant compared with the social effects. The evidence presented in the P.E.P. broadsheet alone suggests that the standard of living in Britain is notably higher than in other European countries, or at least that the British people prefer to put expenditure on television before other expenditure that might raise standards of education, for example. It will not always be easy, in the light of this broadsheet, to counter some of the arguments which we may meet in advancing our own proposals for European Free Trade.

Apart from that, the broadsheet puts a rather different complexion on the debate regarding competitive television and the relations between broadcasting and television which preceded the establishment of the Independent Television Authority and that about the fourteen-day rule, whereby topics to be discussed in Parliament must not be raised during the previous fortnight. The broadsheet does not throw much light on the question whether television is a drug or a stimulant, and it scarcely touches the distinctive qualities of television as a medium. Nevertheless, it indicates the immense potentialities of television—and broadcasting—for informing the public mind and even moulding public opinion, and by implication the desirability of ensuring that public discussion of vital issues is as full and early and also as uninhibited as possible. It is a vital public interest that no irrelevant traditions, even of Parliament, should allow prejudices to be formed and mistaken ideas to be disseminated through an obsolete time schedule; and the replacement of the fourteen-day rule by a seven-day embargo, with most of the limitations lapsing after the second reading of a Bill recommended by a Select Committee of the House of Commons, was a sensible proposal.

It is perhaps premature to judge how far television can be a stimulant, particularly from an informative or educational point of view, without much wider inquiry into the potentialities of television as a medium. In the meantime, the evidence that it does sometimes act as a drug should induce positive action to offset secondary effects which might well be serious and could also create difficulties in the use of television for positive purposes. Published evidence as to the effect of television on social habits and hobbies does not indicate a wide difference between the habits of those owning television sets and those without, in many activities such as sport, gardening, theatre-going and card-playing: the most significant differences appear in reading, attendance at the cinema, church-going and dancing.

Certain activities have been greatly affected by the growth of television; but even so, except for reading, it could perhaps be argued that television could contribute something to offset any loss. A recent thoughtful article on the B.B.C. Third Programme and its relation to broadcasting by Dr. M. B. Counan in the *Universities Review* of February indicates the nature of such reactions and the need for forethought as to the consequences. Dr. Counan does not conceal his belief that the introduction of competitive television was an error of judgment, and urges that we should seek to secure the removal of the present B.B.C. Charter in 1962 or even to reinstate the B.B.C. monopoly. The main interest of his article, however, lies, first in its clear statement of the cultural contribution of the Third Programme, and then in its equally clear analysis of the way in which that contribution has been diminished by the failure to develop and improve it continually and to provide it with sufficient finance and time.

The latter is the vital point, for although *vis à vis* Independent television there is evidence that the B.B.C. has regained some ground, as already noted, this does not apply to sound broadcasting, and what is happening there can happen in other fields also if no effort is made to avert such consequences. As Dr. Counan observes, the influence of the B.B.C. on the cultural life of Britain must diminish even if no further changes are made. Competition with the commercial service for talent and copyright inevitably raises costs and will lead the Corporation to seek a larger licence fee. Such uncertainties, coupled with the knowledge that it is losing ground with the public, make for a lack of confidence and insecurity within the Corporation which is reflected in its programme policy.

What emerges from these preliminary inquiries is the urgent need for more objective thinking and searching, disinterested inquiry into the indirect as well as the direct effects of broadcasting, both sound and television, upon our social life and institutions. That they have immense power, both for good and for evil, over the lives and minds of men and women is widely recognized; but as yet we know relatively little about how to use that influence constructively,

even in education. Meanwhile, there is danger that, apart from their destructive effect upon certain habits and institutions that make for stability and coherence in our social life, those influences may set the minds of men and women in ways which make it even more difficult to achieve the constructive possibilities. To counter that, it is the more important that the utmost use should be made of the opportunities which exist in broadcasting at present, either through the Third Programme or other programmes, of creating, possibly in co-operation with the Press and other means, an informed public opinion which is essential if policy is to be formed and action taken in fields such as defence, education, health or trade. To that end informed public discussion of current issues is a vital contribution.

THE LIFE OF DARWIN

The Autobiography of Charles Darwin, 1809–1882

Edited by Nora Barlow. Pp. 253+4 plates. (London: William Collins, Sons and Co., Ltd., 1958.) 16*s.* net.

LADY BARLOW keeps adding to our debt of gratitude for her untiring care in editing or de-editing the literary remains of her illustrious grandfather.

It is good to have Charles Darwin's original biographical sketch as it was written and left for the information of his children and grandchildren "with original omissions restored". His grand-daughter's notes are helpful and informative, and do not trouble or interrupt the narrative.

About half the book is, however, devoted to new material. There are two appendixes, one of eighteen pages "On Charles Darwin and his grandfather Dr. Erasmus Darwin", and one of more than fifty entitled "The Darwin–Butler Controversy". The six notes which complete the volume are of personal and bibliographical interest, and take only twenty-six pages.

The relationship between Charles Darwin's evolutionary doctrine and that of Erasmus Darwin is treated here in terms of the theories, if that is not too strong a word, held by Charles on the subject of scientific inference. I believe this point of view does less than justice to his grandfather, who wrote in the tradition of didactic poetry, and was, to the taste of his century, one of the greatest of poets. I do not understand that this fact should be ignored merely because, eighty years later, the function of poetry in contemporary literature had changed; and people like Coleridge had written spitefully.

The charge that Charles plagiarized his grandfather's work, and took credit for his ideas, was indeed nothing but a malicious falsification due, I suppose, to Samuel Butler relying on the public's lack of direct familiarity with the work of either. I could wish that Lady Barlow had given half a dozen pages in this first appendix to quotations from "The Botanic Garden" and from the "Zoonomia". The sonorous lines could be annotated from Buffon or Lucretius, lest the reader forget that Erasmus as an eighteenth century *philosophe* was expressing his appreciation of an old and richly poetic idea and not assembling the evidence for an inductive proposition. It would be apparent that Erasmus was not trying to do what his grandson later did, and this not from any lack of understanding of the proper procedure of the natural sciences.

I have, for myself, no doubt that Charles would never have undertaken the large task of marshalling the evidence for "descent with modification", which had indeed become much more impressive since Erasmus's time, without having hit upon a truly naturalistic explanation. Speculation, indeed, has an important part to play in inductive reasoning, but speculation supported by a theory which both Cuvier and Lyell had been forced to reject was to Charles Darwin a major obstacle.

R. A. FISHER

FOOD AND POPULATION

The Grassland and Fodder Resources of India

By R. O. Whyte. (Scientific Monograph No. 22.) Pp. v+437+50 plates. (New Delhi: Indian Council of Agricultural Research, 1957.) Rs. 16; 36*s.*; 5 dollars.

IT has been realized for many years that the grazing and fodder resources of India are inadequate to meet the needs of the livestock population and through them the nutritional requirements of the Indian people. This volume, published by the Indian Council of Agricultural Research, reviews our present knowledge of the extent and use of these resources. The author, who is agronomist with the Food and Agriculture Organization of the United Nations, has worked in close collaboration with Indian grassland specialists for the past five years.

In India, most of the livestock is kept in the villages, and although the working animals and buffaloes are hand-fed to some extent, the cows and young stock suffer severely from malnutrition. The village grasslands are heavily over-stocked, and although they can be regenerated by controlled grazing, even then they can supply keep for only four to five months of the year. The improved herbage does not provide adequate nutrition for high-quality cattle, such as dairy cows, which require supplementary fodder rich in protein. The use of sown leys is precluded in most areas by the large and increasing human population, all the cultivable land being of necessity devoted to food and cash crops with a few annual fodder crops.

The author suggests that the most effective increase in livestock production can be obtained by controlled management of the village grasslands, based on a knowledge of their position in the ecological succession to forest, and supplemented by the conservation of fodder for the dry season, and the use of annual leguminous fodder crops.

In practice, however, these recommendations raise serious religious and social difficulties. The optimum carrying capacity of most village grasslands is far lower than the present livestock population, but the strong religious objection to killing old and surplus cattle makes the necessary reduction in numbers rather improbable in the near future. Furthermore, the small size and fragmented nature of the holdings prevent adequate provision of supplementary fodder. To maintain a family and their necessary animals requires over five acres of irrigated land, and considerably more of dryland, yet over most of India 60 per cent of the holdings are less than five acres.

These problems are social and religious rather than purely technical, and their solution depends on the informed education of the agricultural student and adviser, and through them of the farmer himself. For this purpose the present book is an admirable source of balanced and reliable information, and may well serve as a standard text-book on Indian grassland husbandry.

The standard of production, though not high, is serviceable and the price reasonable. Many of the illustrations of grassland types leave much to the imagination, and the legends on the map of soil types require a strong magnifying glass, but these are minor blemishes on a most timely and useful publication.

J. P. Cooper

PHYSIOLOGICAL ECOLOGY

The Water Relations of Terrestrial Arthropods

By Prof. E. B. Edney. (Cambridge Monographs in Experimental Biology, No. 5.) Pp. vi+109. (Cambridge: At the University Press, 1957.) 15*s.* net.

NATURALISTS have for a long time been aware that insects and many other arthropods live under conditions which often expose them to the danger of considerable desiccation. Physiologists have, in the laboratory, studied the effects of temperature and humidity on these animals, and have discovered mechanisms which enable them to survive under what would appear to be unfavourable conditions. In this book Prof. Edney has brought together the results of these laboratory investigations in such a way that ecologists will be able to find many explanations of their field observations.

Insects, and some other arthropods, are the only 'small' animals which are not either aquatic or restricted to an environment where the air is normally saturated. They are able to live under these conditions because they have a more-or-less waterproof cuticle, and because they have respiratory mechanisms which enable them to take in sufficient oxygen and lose a corresponding amount of carbon dioxide without also losing an excessive quantity of water. There are, of course, limits to the efficiency of these processes, and it is probably the need to respire which finally limits the distribution of many insects. We have known for twenty-five years that, of the water which is evaporated from insects, particularly those adapted to dry environments, practically all is lost through the respiratory spiracles, and scarcely any through the general surface of the cuticle, but a full elucidation of the nature of this cuticle, and the reasons for its remarkable properties, has taken a long time, and work is still proceeding. Prof. Edney devotes nearly a third of his text to an admirable account of our present knowledge of this subject, and he makes it as easy to understand as is possible when dealing with such an essentially complicated subject.

The second way in which these animals withstand dry conditions is by having developed excretory mechanisms which function with the minimum loss of water. Not only have they evolved means of eliminating waste nitrogen in insoluble forms (uric acid, guanine) which can be voided without any substantial loss of water, so that the urine is often practically solid, but also many have complicated mechanisms which cause the fæces also to be bone-dry. These mechanisms cannot, however, prevent considerable fluctuations in water content and in the concentration of salts and other substances in insect tissues. The ability of the insects to function normally while these changes are taking place is a further important reason for the success of the group in colonizing such a wide range of habitats. It may seem surprising to find that five pages of this short book of only 93 pages of text on terrestrial arthropods are devoted to osmotic regulation in aquatic forms, but the work described here is clearly relevant to the main argument and its inclusion is fully justified.

The ways in which arthropods gain water is also discussed. Considerable space is devoted to the interesting, and still unsolved, problem, of how some arthropods take up moisture from unsaturated air. This problem, though interesting to the physiologists, is of only minor importance in ecology, and it would perhaps have been better to have devoted more attention to the commoner methods by which water is gained. It is surprising, for example, to read that "drinking of liquid water—is confined to adults; larvæ obtaining their water with the food". The naturalists who preceded the present generation of ecologists were familiar with the way in which caterpillars would drink, and one species, the drinker caterpillar, was particularly well known in this connexion. This is, however, only a minor point, and it is very satisfactory to find the sometimes controversial question of metabolic water so clearly dealt with.

The body temperature of small animals is normally very close to that of the atmosphere, but may be higher due to insolation, and lower due to evaporation. Such cooling is relatively uncommon as it leads to desiccation, but Prof. Edney himself has shown that in woodlice it may not be unimportant. As a whole these animals supplement the physiological mechanisms by their behaviour; they can not only withstand some exposure to unfavourable conditions, they are also able to react in such a way as to find the least unfavourable positions within their environment.

Kenneth Mellanby

THERMO-ELECTRIC POWER

Semiconductor Thermoelements and Thermoelectric Cooling

By A. F. Ioffe. (Translated from the Russian.) Pp. vii+184. (London: Infosearch, Ltd., 1957.) 42*s.*; 6 dollars.

IN the early years of this century the possibility of using the thermo-electric effect to produce electrical power was explored. The idea was abandoned because of the relatively small thermo-electric powers of metal junctions. The more recent development of semiconductors with controlled constitution and physical characteristics has caused a revival of interest in the thermo-electric generator and also in the use of the Peltier effect to provide a refrigeration unit, since semi-conductor junctions provide relatively large thermo-electric powers. In the present book Prof. A. F. Ioffe has combined two other works, one on the basic theory of thermojunctions and the other on application of thermojunctions to refrigeration. In his Institute for Semiconductors of the Soviet Academy of Sciences considerable effort has been given to the development of efficient semi-conductor thermo-elements, both for power generation and for refrigeration. It is clear from the text that the Institute is fully aware of the basic problems involved

and has made progress which compares very favourably with that in Britain and the United States.

In the first part of the book, following a brief historical introduction, the author presents the fundamental theory of the various thermo-electric effects and gives special attention to the problems raised by the different statistics of degenerate and non-degenerate semi-conductors. He then gives the important criteria for efficient thermojunctions and finally derives the well-known efficiency factor which is the square of the thermo-electric power divided by the product of thermal conductivity and electrical resistivity. In giving the conditions for optimum performance the text provides a very useful discussion of the influence of such effects as phonon and impurity scattering of charge carriers. As regards experimental material, mention is made of the PbSe–PbTe and the Bi_2Te_3–Sb_2Te_3 series as sources of efficient semi-conductors for thermo-electric devices.

To some extent the combination of two books produces repetition of material from the first part in the second part of the text; for example, the efficiency factor is re-presented. The second part includes an interesting summary of the experimental studies made on the selenides and tellurides mentioned above. As shown by other workers in the West, the principal problem is to prepare semi-conductors with suitable impurities so that a reduction in the thermal conductivity is obtained without a corresponding decrease in electrical conductivity.

In the last chapter of the book interesting examples of practical refrigerator units are given, while elsewhere examples of power generators (one suitable for mounting over a paraffin-lamp glass for supplying power to a radio set) are included. Although *n*-type PbTe–PbSe combined with *p*-type Sb_2Te_3 appears to be the junction used in many refrigeration units, there is a noticeable absence of specification of the junction used in the later developments where a temperature difference of 70° C. is claimed between hot and cold junctions.

On the whole, this book is a very welcome addition to the relatively sparse collected literature on semi-conductor thermo-electric devices. It is lucidly written and shows an appreciation of the contemporary position in the West at the time of writing. It is to be hoped that more translations of Russian texts on solid state physics will quickly follow this one.

G. F. J. GARLICK

ELECTRICAL PROPERTIES OF MATERIALS

Handbuch der Physik

Herausgegeben von S. Flügge. Band 17: Dielektrika. Pp. vi+406. 94 D.M. Band 19: Elektrische Lietungsphänomene I. Pp. vi+411. 82 D.M. Band 20: Elektrische Leitungsphänomeme II. Pp. vii+491. 112 D.M. (Berlin: Springer-Verlag, 1957.)

THE three volumes in question are concerned with the theoretical physics underlying the electrical properties of materials, some of which have great technological importance. In general, the aim of the editors is to cover the theory as completely as possible, but several of the articles cater for the experimentalist who is looking for physical meaning, as well as for the pure theoretician. The bibliographies given seem up to date to 1955 or 1956; as a small point of criticism it may be mentioned that there is no consistent policy as to whether references should be given in footnotes or collected at the end of each article. Some articles are in English, some in German, and one is in French. The general index at the end of each volume is given both in German and English, with translations. The printing of the mathematical formulæ is of a luxurious standard.

Volume 17 contains three articles of about equal length. The first, on "Dielectrics", by W. Fuller Brown, covers the theory of the static dielectric constant and dielectric loss. The author gives a somewhat cumbersome text-book presentation of the subject with the emphasis on formal electrostatics. There is a short section on recent work on microwaves. The article on "Electrical Breakdown", by W. Franz, in German, contains a historical survey of the subject which is somewhat out of date on the technological side, and chapters on thermal and intrinsic breakdown. The main interest of the article lies in a discussion of the different theories of intrinsic breakdown, given with a fair amount of mathematical detail. The article on "Piezoelectricity, Electrostriction and Ferroelectricity", by P. W. Forsberg, unifies its three subjects on the basis of a treatment by tensors. This presentation leads to a certain amount of repetition, but the article reviews much recent material, and contains a wealth of beautiful illustrations.

Volume 19 is written wholly in English. J. C. Slater contributes an article on "The Electronic Structure of Solids" which introduces the reader to a subject which is the basis of a large part of Volumes 19 and 20. The article is chiefly concerned with the theory of electrons in a periodic lattice in terms of the band model, and contains sections also on cohesive energies and elastic properties and on magnetism. The author frequently includes discussions in non-mathematical terms particularly where the physical meaning of approximations is concerned. The second article, by A. N. Gerritsen, "Metallic Conductivity, Experimental Part", concentrates on work after 1945. The article covers metallic conductivity as a function of physical parameters and of crystal structure and imperfections, and contains many tables and graphs. H. Jones contributes an advanced and condensed treatment of the "Theory of Electrical and Thermal Conductivity in Metals". In particular, he gives chapters on conductivity at low temperatures and the anomalous skin effect, and he treats *Umklapp* processes more fully than usual. G. F. J. Garlick, in an article on "Photoconductivity", gives a relatively short theoretical introduction and proceeds to give a tightly packed review of post-war work, largely experimental. There is little overlap between this article and the article on semiconductors in Volume 20.

About half of Volume 20 consists of an article on "Semi-conductors" by O. Madelung, in German. This is theoretical, with the emphasis on statistical thermodynamics, but the presentation caters for the experimentalist. About 100 pages are devoted to the theory of homogeneous semi-conductors in and out of equilibrium, with the emphasis on electrical conduction, while some 30 pages deal with *p–n* junctions, leading logically to the theory of transistors. Surfaces and contacts are also discussed, and the

author gives a summary of the experimental methods for the determination of the most important parameters of semi-conductors. Optical and magnetic properties are only touched on. The article on "Ionic Conductivity", by A. B. Lidiard, in English, is also theoretical with the emphasis on statistical thermodynamics and physical meaning. It gives an integrated picture of a subject the references to which are otherwise widely scattered. The author discusses intrinsic and structure-sensitive conductivity, and gives a section on alternating-current phenomena which is incidentally of dielectric interest. J. M. Stevels, in a comprehensive article in English, reviews the electrical properties of glass. He takes the structure as read and treats dielectric properties and electrical breakdown as well as electrical conduction. For the last article there is a change in physical imagery as well as in language, since the subject is concerned with liquids instead of solids, and the language happens to be French. E. Darmois, in an article on "Electrochemistry", gives a fairly comprehensive introduction to the theory of electrolytes and then reviews such less accessible subjects as electrocapillarity, the theory of the double layer, and electrokinetic phenomena.

CONTRIBUTION OF RADIOBIOLOGY TO GENERAL BIOLOGY

Symposium on Antibodies

Their Production and Mechanism of Action. (Given at Research Conference for Biology and Medicine of the Atomic Energy Commission. Sponsored by the Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee; held at Gatlinburg, Tennessee, April 8–10, 1957. Reprinted from the *Journal of Cellular and Comparative Physiology*, Vol. 50, Supplement 1, December 1957.) Pp. x+361. (Philadelphia: The Wistar Institute of Anatomy and Biology, 1957.) n.p.

THE biological changes produced by ionizing radiations began to be studied immediately after Röntgen's discovery of X-rays, but it is only in the past fifteen years that the research effort put into radiobiology has really gained momentum. The dividend reaped has extended far beyond original expectations, and this applied research has contributed very greatly to the progress of general biology. It is a good illustration of how fundamental discoveries can spring from researches directed to a more immediate and practical end.

The annual research symposia organized by the Oak Ridge National Laboratory since 1947, on a wide range of biological topics, have played an important part in making radiation studies an integral part of contemporary biology. The subjects chosen have shown a great awareness of the trend the researches are taking and have brought together experts just at a time when the particular subject was advancing rapidly. As an example the seventh conference of the series, in 1954, may be mentioned. It dealt with genetic recombination from different aspects, and by doing so synthesized our observations on bacterial transformation and transduction and stimulated the measuring of genetic distances in molecular dimensions. This particular conference applied the Watson-Crick model of deoxyribonucleic acid on the chromosomal level, and developed new concepts which have helped considerably in the analysis of various problems of cytology and genetics. In some of the symposia, such as those on genetics, the influence of radiation formed an integral part of the topic discussed; while in others, such as those devoted to the biochemistry and biophysics of important macromolecules, radiation did not enter into the main papers at all though its relevance to the subject was brought out in the well-edited discussion.

The tenth meeting, held in April 1957, and published like all the others as a supplement to the *Journal of Cellular and Comparative Physiology*, is typical. Its subject: "Antibodies: their Production and Mechanism of Action", provided an excellent forum for the discussion of the interesting problems which arose in connexion with the application of a new method, for enhancing, and in certain instances achieving, the complete recovery of experimental animals from radiation injury. The method, first suggested by the observation of Lorenz and his collaborators in 1951, consists of the transplantation of blood-forming tissues such as the bone marrow, into animals whose hæmopoietic organs are destroyed by irradiation, and has been intensively studied in many laboratories. Progress has been rapid, particularly since 1955, when D. L. Lindsley and his colleagues (Oak Ridge) demonstrated, by using genetic markers which differentiated between host and donor, that the transplanted donor tissue took over the function of blood formation. The cytological proof that the donor cells recolonize the irradiated bone marrow was provided in the following year by J. F. Loutit and his group in Harwell. Work from several centres was summarized at the conference by C. C. Congdon and T. Makinodan of Oak Ridge, J. F. Loutit, C. E. Ford and N. A. Mitchison of Britain, and by D. W. van Bekkum and O. Vos of Holland.

The discussion of the extremely intriguing immunological consequences (for example, the co-existence of two genetically different tissues in 'chimeras'; the nature of homograft reaction; the degree of cellular adaptation; the mechanism of actively acquired tolerance) was introduced by the papers of leading immunologists and biochemists dealing with fundamental aspects of immune reactions. The induction, rate of synthesis and degradation of antibodies were discussed by W. H. Taliaferro (Chicago); the nature of the antigen-antibody reaction was described by J. F. Dixon (Pittsburgh), S. J. Singer (Yale University), R. W. Wissler and his collaborators (Chicago), and the diversity of antibodies was analysed by D. W. Talmadge (Chicago). The relationship between immunological specificity and chemical structure was the subject of E. A. Kabat's (New York) presentation. R. S. Schweet and R. D. Owen (Pasadena) discussed the nature of the change which may occur in cells responsible for antibody formation, and presented a challenging scheme postulating that the foreign antigen impinges on the nuclear deoxyribonucleic acid of the host and that the process may be considered to be similar to that of bacterial transformation; while G. D. Novelli and J. A. DeMoss (Oak Ridge) considered current concepts of protein synthesis. The symposium brought together much basic information which may enable us to apply the new method in the therapy of human leukæmias, and showed that the time has arrived for discussing the mechanisms which may be responsible for cellular variation. This formed the subject of the eleventh symposium which was held in April of this year with

the title "Genetic Approaches to Cellular Variation" (see *Nature*, 181, 1706; 1958).

Of the many research centres devoted to radiation, the Biology Division of the Oak Ridge National Laboratory has for long been in the forefront not least because it realized the need to integrate this polyglot subject with the advancing fronts of biological research. Last year's symposium is further evidence to show the far-reaching influence of these conferences and the foresight of their organizer, Dr. A. Hollaender.

P. C. KOLLER
P. ALEXANDER

PHYSICAL CHEMISTRY AT HIGH PRESSURES

Physico-Chemical Effects of Pressure

By Dr. S. D. Hamann. Pp. ix+246. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1957.) 42*s*.; 8.50 dollars.

THERE are several books concerned either with high-pressure technology or with the physics of high pressure, but this is the first to bridge the gap between these two subjects. Dr. S. D. Hamann, of the Commonwealth Scientific and Industrial Research Organization, Australia, has performed a valuable service in providing a concise summary of the effects of pressure in the field of physical chemistry. Although the book will be mainly of interest to physicists and chemists engaged in high-pressure research, it will also provide chemical engineers with a theoretical background to the subject.

The first part, dealing with the techniques of experimenting at high pressures, is concerned with the principles of small-scale experimental apparatus and, in particular, with those techniques, such as the generation of high transient pressures by shock waves, which have been developed during the past decade. The omission of the detailed information that is so essential in the design of high-pressure apparatus is offset by the provision of numerous references to original publications. The discussion of the effects of pressure on compressibility, phase changes, transport properties, electrolytic conduction and dielectric and optical effects deals in the main with changes brought about by pressures greater than one hundred atmospheres. In spite of this restriction, there are omissions, and some of the sections are of necessity very brief; neverthless, the treatment, which is largely theoretical, is well illustrated by carefully chosen data. The author is well known for his work on the equilibria and kinetics of chemical reactions under pressure, and the last part of the book, which contains authoritative chapters on these topics, will be of great interest to chemists. Two appendixes are provided; one containing a bibliography of Bridgman's measurements of the compressions of liquids and the other information about the effect of pressure on the freezing temperature of liquids.

Throughout the book an admirable balance between theory and experiment is maintained. Except in the section dealing with the strength of thick-walled cylinders, empiricism has been largely avoided, and an attempt has been made to give molecular models of the underlying causes of the pressure effects. In the words of the author, it is likely that time will prove some of the models wrong, but in the meanwhile they will have a use if they merely stimulate further research.

K. E. BETT

VETERINARY HANDBOOK

The Merck Veterinary Manual

A Reference Handbook of Diagnosis and Therapy for the Veterinarian. Second printing. Pp. ix+1398. (Rahway, N. J.: Merck and Co., Inc., 1957.) 7.50 dollars.

THIS publication, produced by the Merck Pharmaceutical Company of the United States of America, is intended as a reference handbook of diagnosis and treatment for the use of veterinary surgeons. Among the stimuli to its preparation was the wide and enthusiastic reception given to a similar handbook prepared for the medical profession.

While encyclopædic tomes of this type (it comprises 1,350 closely packed pages) inevitably have many weaknesses, it must be stated at once that this is a serious and, in measure, very successful attempt to provide the veterinarian with concise, authoritative and readily available information on the diagnosis and treatment of diseases of domestic animals. Emphasis, of course, has been placed on those conditions occurring in North America.

Not the least of the problems arising in the preparation of a book such as this is the matter of classification. This is greater in veterinary medicine than in human medicine because of the number and variety of species the former deals with, and the diversity of the pathological conditions encountered in them. In this manual the classification is primarily under the respective body systems, and the various diseased conditions, whether they come under the heading of general pathology or contagious disease, of each species are included. Exceptions are poultry and the non-domestic animals, which have sections to themselves. It is confusing to find diseases of cattle, sheep and pigs, horses and dogs, dealt with under the same systematic headings. One would have preferred to see each of the important species dealt with separately and the contagious diseases separated from the general ones. Surgery does not receive more than a mention when appropriate; nevertheless, those who practise in the veterinary field know that the division between clinical medicine and surgery is a purely arbitrary one and not infrequently that which may be classified as medicine necessitates surgical interference. As is the custom with books of this type, one starts with the name of the disease and then reads all about it. This, of course, is the opposite from that which prevails in the field. One commences with the animal and is primarily concerned with the clinical signs it exhibits. This is followed by a detailed examination of the various systems of its body with the view of ascertaining the site and, even more important, the extent of the disease. Its name is the last point. The task of the veterinary surgeon differs from that of the doctor in that he is chiefly governed by the economics of agriculture and thus he must accurately assess what the animal's chances of recovery are; thus prognosis is often more important than treatment. These are things that can only be taught by skilled diagnosticians working at the veterinary equivalent of the bedside and by pathologists in the post-mortem room. No book can effectively replace them.

The Merck Company are to be complimented for producing what is, of its type, an excellent book and one which, despite the criticisms made, will be found most useful to veterinary surgeons. It should be stated that it is completely free from any suggestion of advertising material.

J. G. WRIGHT

The Twice-Born

A Study of a Community of High-Caste Hindus. By Dr. G. Morris Carstairs. Pp. 343. (London: The Hogarth Press, Ltd., 1957.) 30*s*. net.

THE title of this book suggests that it is a study of the Brahmins of India and of their relations with the other superior castes. But this is not so. It is the study of a single social unit, the village of Deoli, and it is formulated from a psychological point of view, and not as a factual description. The author begins by stating his belief that it is in "the legacy of realistic imaginative writing to which the long association with Britain gave rise" that projections of Indian life as it is may best be found. Imagination is not, perhaps, to be demanded of official publications, but it should not be forgotten, in India or elsewhere, that since the issue of the first District Gazetteers in the 1860's, the Indian Government strove to publish the facts on which its actions were based. This mass of record and comment has still much to teach the serious student.

Dr. Margaret Mead in her preface describes this book as "a study of the differences in character which characterize three different castes in a remote and only recently modernized community". But caste is a Portuguese, not an Indian, word, and remote is a doubtful qualification in a sub-continent the people of which are such inveterate travellers and where accurate information frequently beats the post and Press. India has been modernized many times. Roman trade did it in the first century A.D. and the Aryans, indeed, did it before that. India has never been out of the world. Deoli had no wireless, but a decade of broadcasting, two decades of travelling cinemas, and the existence of a flourishing colloquial Press for more than a century, forbid naïvety.

The introductory chapters are curiously discursive. A party of Bhils intrudes into Chapter 8, unfortunately only to display the author's lack of preparation. For Bhils abound in these parts and the literature is adequate. The bulk of the book consists of recorded conversations with three chief informants, some of their written statements, and psychological tests.

On p. 307 it is stated that, in the word association test, Puranmal Mehta gave a delayed response to "Vagina", "Anger", "Girl", "Fæces", "Penis", and "In-laws". So should I. Oh, Seligman! Oh, Haddon! Oh, Balfour! K. DE B. CODRINGTON

Araucanian Child Life and Its Cultural Background

By Sister M. Inez Hilger. (Smithsonian Miscellaneous Collections, Vol. 133, Whole Volume.) Pp. xx+439+80 plates. (Washington, D.C.: Smithsonian Institution, 1957.) n.p.

THE Araucanians of Chile and Argentina have retained their language and a good deal of their original culture after more than 400 years of contact with Europeans; much has been written about them, but little of this literature has been specifically concerned with the children. Sister Inez Hilger had much previous experience of child studies among North American Indian tribes, so she was well prepared to undertake this extensive and sympathetic account. The book contains much information about the people in general, since this is necessary to an understanding of the children. Its scope is best described by a quotation from the first sentence of the preface, "The purpose of this study is to record the ethnography . . . of the Araucanians . . . particularly their customs, beliefs and traditions in relation to the development and training of the child", and a psychological approach is expressly disclaimed, though certain psychological aspects emerged and others are implicit.

The book is clearly written and well illustrated; it maintains the high standards of the Smithsonian Institution. G. H. S. BUSHNELL

Gas Dynamics

By Klaus Oswatitsch. English version by Prof. Gustav Kuerti. (Applied Mathematics and Mechanics, Vol. 1.) Pp. xv+610. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1956.) 12 dollars.

FIRST published in German in 1952, and now translated with only minor amendments, this excellent book on compressible fluid dynamics stands little diminished in value by the continued rapid development of its subject. Its distinction rests in the high degree of success with which Dr. Oswatitsch has related methods of analysis to physical understanding.

The first part of the book deals with both steady and time-dependent 'one-dimensional' gas flows; a wide range of topics is covered, including, for example, problems of combustion and detonation. The method of characteristics is introduced for unsteady flow. A lucid exposition of the equations of motion for flow in three dimensions follows, with more emphasis than usual on their integral forms. Attention is then narrowed to steady adiabatic inviscid flow, and the fundamentals and analytical methods of high-speed aerodynamics are surveyed in a section which occupies about half the book. Basic similarities and differences between various types of flow, and parallels with unsteady flow, are carefully brought out. The last two chapters are rather too-abbreviated sketches of the influence of viscosity and experimental methods.

This can be highly recommended as an illuminating and authoritative account, perhaps most useful to the reader who already has some acquaintance with the subject. E. P. SUTTON

Common Medicinal Plants of Darjeeling and the Sikkim Himalayas

By Dr. K. Biswas. Pp. vi+157+50 plates. (Alipore: West Bengal Government Press, 1956.) Rs. 7; 11*s*. 3*d*.

THIS book, which has the benediction and recommendation of Sir Ram Nath Chopra, well known for his scientific work on drugs, opens with a chapter on "Herbal Charms" and does not seem to recover from this mixture of sorcery, magic and folklore. After the startling success of the alkaloids of *Rauwolfia serpentina* in the treatment of high blood pressure, it would be unwise to dismiss miraculous claims for some plants as baseless, but what is one to make of the following extracts? "*Drymaria cordata*: used as a medicine for dog-bites, and is also very useful as a throat paint in hay-fever, hay-asthma, diphtheria and pneumonia". "*Rhus succedanea*: juice of the leaves is said to blister the skin, used in curing indigestion and vomiting in children." Bald-pates may take hope, for *Nardostachys* "has the property of increasing growth of hairs on the head". Those who sigh for their lost youth need not despair for "*Curculigo orchioides* . . . taken with honey and cow's milk prevents weakness due to old age and bring (*sic*) in young strength and spirit in old men and women producing freshness in face and body". The book abounds in misprints and the half-tone plates are miserable. The line drawings are reasonably presentable. N. L. BOR

VARIANCE CONTROL IN THE ANIMAL HOUSE

By Dr. J. D. BIGGERS, Dr. ANNE McLAREN and Dr. DONALD MICHIE
Royal Veterinary College, London, N.W.1

THIS article is concerned with the production of uniform laboratory animals, a subject which is of direct interest to any research worker using animals in his experiments, any organization using animals for the standardization of biological products, and also to any person concerned with the management of an animal house supplying several workers. Our interest in this problem stems from several years study on methods of controlling variation in mice, but the conclusions are applicable to work with other species.

Information in an Experiment

When we carry out an experiment we are usually interested in the value of some parameter, for example, the difference between two means, a regression coefficient or a relative potency in a biological assay. An estimate of the parameter is calculated from the observations and is subject to some uncertainty, the magnitude of which is measured by the variance of the estimate. This variance is proportional to the overall variance (the square of the standard deviation) of the responses or other biological properties being studied.

The information on a parameter is defined as the reciprocal of its variance. In practice, the amount of information that we require from an experiment is fixed by the limits of error of the estimate which we are prepared to tolerate. Thus, the more uniform we make a basic population the fewer individuals will we require to obtain the fixed amount of information. Methods of controlling the overall variance of populations are therefore of prime importance.

Causes of Variation

The variation of a group of animals, with respect to any measured character (for example, the response to a treatment), depends upon: (1) genetic factors, (2) environmental factors with persistent effects, and (3) environmental factors with transient effects. On the 'classical' model the total variance is considered as the arithmetical sum of the effects upon the animals of variation in these three categories. This view is now known to be an over-simplification. In each category we should further distinguish between those factors which increase the variance by varying from one animal to another, and those factors which act uniformly throughout the group but affect the degree to which the animals are influenced by other factors which do vary. Hitherto, attention has been focused on the varying factors. In this article we wish to direct attention chiefly to the role of uniform factors in controlling variability.

Genetic Factors

The more the individuals of a group differ in their genes, the more variable, other things being equal, will the group tend to be. The genetic differences between animals were for many years held to constitute the main cause of variation, provided that the animals were kept under uniform environmental conditions. The idea, therefore, developed that very uniform animals could be obtained by inbreeding, since in this way genetic differences between individuals can be minimized. This approach ignored the possible effects of uniform genetic factors upon variability: the genetic constitution of a population may influence the level of phenotypic variability even though all the members of the population have the same genetic constitution. In particular, it has been shown in recent years that a genetically uniform and homozygous population (an inbred strain) may be strikingly more variable than a population which is genetically equally uniform but heterozygous (the F_1 hybrid generation between two inbred strains).

The potential use of F_1 hybrids for biological assay was realized in 1946 by Mather[1], following his observation that F_1 hybrids between inbred strains of the Chinese primrose were more uniform than the parent strains. Unfortunately, this suggestion did not receive immediate attention from biological workers. In 1954, McLaren and Michie[2] and Biggers and Claringbold[3] (in ignorance of each other's and of Mather's work) reiterated this view as a result of investigations on the response of mice to 'Nembutal' narcosis and œstrogens, respectively. At that time few studies were available to indicate the generality of the phenomenon, but in the past three years a considerable literature has appeared. In 1954, Lerner[4] published his monograph, "Genetic Homeostasis", in which earlier work on the relative variability of homozygotes and heterozygotes is reviewed. The conclusion from this work was that for naturally cross-breeding species the heterozygous condition was likely to be more stable in face of environmental influences with persistent effects than the homozygous condition. In naturally inbreeding species we cannot necessarily expect the same to hold.

Table 1 provides a summary of the papers on naturally cross-breeding animal species which have appeared since Lerner's monograph. It can be seen that the relative uniformity of F_1 hybrids between inbred strains is a widespread phenomenon covering a large range of species and characters. There are two papers, however, which require comment. Grüneberg's findings[5] on a variety of anatomical characters in the mouse might suggest that only in a few cases are the F_1 hybrids more uniform than the inbreds. It must be stressed, however, that all but four characters are of the 'all-or-none' type, and that a variance calculated by the binomial theorem from the percentage incidence of such a character bears no direct relation to the variance of quantitative characters with which we are concerned. In the remaining four cases described by Grüneberg there is one instance where the F_1 is more uniform than the inbreds, two cases where the uniformity of the F_1 is about equal to that of the more uniform of the two parent strains, and one case where the inbreds are more uniform. The paper by Chai[10]

Table 1. Comparisons of Variability between Inbred Strains and F_1 Hybrids between them
The list only includes papers not found in the review by Lerner

Author	Species	Character	Result of comparison
McLaren and Michie (ref. 4)	Mouse	Duration of 'Nembutal' narcosis	Inbred more variable
McLaren and Michie (ref. 5)	Mouse	No. of lumbar vertebræ	Inbred more variable
Claringbold and Biggers (ref. 6)	Mouse	Response of the vagina to œstrogens	Inbred more variable
Yoon (ref. 7)	Mouse	Time of vaginal opening	Inbred more variable
Cuthbertson and Tomich (ref. 8) (quoted by Bacharach)	Mouse	Susceptibility to streptomycin sulphate	Inbred more variable
Grüneberg (ref. 9)	Mouse	Various morphological characters	See text
Chai (ref. 10)	Mouse	Response of seminal vesicle to testosterone	See text
Shultz (ref. 11)	Fowl	Egg shape, egg weight, shank length	Inbred more variable
Clough and Cock (ref. 12)	Fowl	Body weight	Inbred more variable
Mather (ref. 13)	*Drosophila*	Sternopleural bristle number	Inbred more variable
Thoday (ref. 14)	*Drosophila*	Sternopleural bristle number	Inbred more variable
*Maynard Smith and Maynard Smith (ref. 15)	*Drosophila*	Eclosion time	Homozygotes more variable
Reeve and Robertson (ref. 16)	*Drosophila*	Bristle number	No significant difference

* The comparison was between flies homozygous and heterozygous for a marked chromosome.

claims to show that there is no difference between the variability of F_1 hybrids and inbreds with respect to the response of the seminal vesicles to testosterone. In setting up his experiment, however, he applied the restriction that the mice should have body-weights between 9 and 12 gm. Since the weight of the seminal vesicle is likely to be highly correlated with body-weight, this restriction may have artificially brought the inbreds and F_1 hybrids being compared within the same range of variability.

The realization that F_1 hybrids were generally less variable than their inbred parents raises the question of the relative variability of inbred and random-bred animals. It seems quite possible that for some characters the greater genetic heterozygosity of random-bred animals might lead to their being phenotypically less variable than inbred animals, in spite of being genetically more variable. The use of inbred strains in biological assay and other quantitative work was stimulated in the early 1920's by King's pioneer work[17] on the growth of inbred and random-bred rats. Her observation that variability was reduced in the inbred population has unfortunately no clear-cut interpretation, since she practised selection for large body-size on the inbreds but not on the random-breds. Biggers and Claringbold[2] traced the history of this subject up to 1954 and concluded that there was no experimental proof that inbred strains were less variable than random-bred animals. The available literature is summarized in Table 2. The list is doubtless not comprehensive, but so far as we are aware it is not selected.

The results summarized in Table 2 make it clear that, unlike the comparison with F_1 hybrids, no general law can be asserted on the comparison of inbred strains with random-bred stocks. It is true that where inbred strains have been compared with unrelated random-bred stocks (Table 2, *B*), in only one instance were the inbreds less variable. But in the cases where the inbreds were compared with random-bred descendants of the same original population (Table 2, *A*) we find the inbreds to be in some instances more variable and in others less. This is not surprising, since we are dealing with the balance between two factors, both making for increased phenotypic variability—the genetic variability of the random-breds and the genetic homozygosity of the inbreds. We may expect the balance to shift from one strain or colony to another and from one character to another.

There is a practical conclusion for the experimental worker who does not wish to go to the considerable trouble and expense of maintaining inbred strains for the production of inter-strain F_1 hybrids. His most effective procedure will be to make an empirical choice from a number of random-bred colonies of that one which shows the least variability in the characters to be studied.

It is an attractive idea that one might be able to breed for uniformity, by selecting as the parents in each generation individuals falling within some restricted fraction of the total range of variation. The idea, unfortunately, receives no support from the available evidence. In fact, an *increase* of phenotypic variation has not uncommonly been encountered (see, for example, MacArthur[25], and Robertson and Reeve[26]). The possibility remains that selection from the middle fraction of the range might succeed where selection at one or other extreme fails. Falconer[27] has, however, tested this idea in *Drosophila*, and reports negative results.

It seems, then, that no purely genetical device for suppressing variability has yet been found to equal

Table 2. Comparisons of Variability between Inbred and Random-bred Animals

(*A*) Comparisons between inbred strains and the random-bred stocks from which they were derived

Author	Species	Character	Result of comparison
King (ref. 17)	Rat	Body weight	Random-bred more variable (but see text)
Morrell and Allmark (ref. 18)	Rat	Susceptibility to toxicity of neoarsphenamine	No significant difference
Rollins and Cole (ref. 19)	Rat	Response to gonadotrophins	Random-bred more variable
Kushner and Kameneva (ref. 20)	Fowl	Body size and hæmatological characters	Inbred more variable
Rasmuson (ref. 21)	*Drosophila*	Bristle number	Most inbred lines slightly less variable, some very much more variable
Reeve and Robertson (ref. 22)	*Drosophila*	Body size	Random-bred more variable

(*B*) Comparisons between inbred strains and unrelated random-bred stocks

Author	Species	Character	Result of comparison
Emmens (ref. 23)	Mouse	Vaginal cornification in response to œstrogens	Inbred more variable
McLaren and Michie (ref. 4)	Mouse	Duration of 'Nembutal' narcosis	Inbred more variable
Winton (ref. 24)	Rat	Susceptibility to toxicity of red squills	No significant difference (see Biggers and Claringbold, ref. 2)
Reeve and Robertson (ref. 22)	*Drosophila*	Body size	One inbred line more variable, one less variable

that suggested by the facts presented earlier: namely, the 'screening' of the F_1 hybrids of a number of strain combinations, or even the screening of random-bred closed colonies, in order to find a combination, or colony, with a low variance with respect to the character or response which is to be studied. A screening programme of this sort could, with advantage, be undertaken for the benefit of biological workers in general by some central organization, and we are informed by the Director that the Laboratory Animals Centre of the Medical Research Council has a project of this nature in hand, using mice. It should, however, be emphasized in the light of the next section on environmental effects that no comparison between different kinds or populations of mice can have any general validity unless the groups compared are raised under identical conditions of husbandry.

Environmental Factors

The properties of an environment, for example, temperature, humidity, composition of the diet, may vary from animal to animal during the formative period of their lives and in so doing will, of course, lead to the production of correspondingly variable animals. It is for this reason that so much effort has been expended in order to standardize conditions of, for example, temperature and diet in the breeding of laboratory animals. But again, the effect of uniform environmental factors upon variability has been virtually ignored in the past, although it has been briefly discussed by Michie[28] and by McLaren and Michie[4].

There are several reports in the literature which suggest that sub-optimal conditions may cause increased variability, even if they are uniformly sub-optimal from animal to animal. By 'sub-optimal' we mean simply conditions which deviate from those in which the given species or strain is known to be most vigorous, prolific and healthy. Increased phenotypic variability has been shown to result from both abnormally high and abnormally low temperatures in peas[29], high temperatures in *Drosophila*[14], malnutrition and reduced illumination in poultry[30] and inadequate diets in mice[31]. The work of Thoday[14] with *Drosophila* is particularly interesting since he showed that a raised temperature increased the variance of the sternopleural bristle number in both inbred strains and F_1 hybrids between them, the increase in variance being greater in the inbreds.

We have recently taken part in an experiment specifically to analyse the effect of uniform extreme climatic environments on the variability of growing mice as judged by their body-weights[32]. Table 3 shows that both the hot and the cold environments greatly increased the overall variance of the animals in both sexes. A large part of the effect was due to an increased variation among the mean values of the different litters, but a significant fraction was contributed by an increased variability among littermates.

Table 3. $10^3 \times$ THE OVERALL VARIANCES OF LOG BODY-WEIGHT IN THREE DIFFERENT ENVIRONMENTS (from Asboub *et al.*, ref. 32)
Reproduced by permission of the Royal Society

Week	Females		
	Hot	Temperate	Cold
1	722	391	1,224
2	1,044	317	1,894
3	874	402	2,501
4	690	363	3,006
Week	**Males**		
	Hot	Temperate	Cold
1	763	458	1,093
2	801	344	1,361
3	641	518	1,629
4	575	502	1,799

The conclusion which we draw from this and the other findings summarized in this section is that the control of variability is not sufficiently ensured by establishing conditions in the animal house which act uniformly throughout the colony. These conditions must also be, so far as possible, optimal for the species or strain concerned.

Persistent Effects upon Variability: 'Constitution'

The variation which is determined genetically, together with that which is due to environmental conditions which have left a permanent imprint on the phenotype, may be termed the 'constitutional' component of the total variation. Its measurement may be used for classifying a group of animals into sub-groups which are more uniform than the original entire group as shown by subsequent tests. Biggers, Claringbold and Emmens[33] demonstrated this fact by classifying ovariectomized mice into sub-groups based on the response of the vagina to œstrone applied directly to the epithelium. The relative uniformity of the sub-groups persisted for ten weeks, at which time the experiment was discontinued. When, however, œstrone was administered systemically to the same animals by subcutaneous injection, the variability of the sub-groups was found to be as large as that of the original population. A reverse experiment showed that sub-groups more uniform than the original group could likewise be produced by tests using the subcutaneous route, but that the variability was as great as that of the original group when tested by the local intravaginal application of the hormone. Thus quite different factors of a constitutional nature may dominate the magnitude of the response according to the method of applying the stimulus.

Environmental Factors with Transient Effects

In contrast to the 'constitutional' component of variation there is finally a component due to environmental factors with transient effects. For example, two colonies of mice were used by Biggers[34] for the assay of locally applied œstrone at approximately 2-week intervals over 42 and 50 weeks, respectively. The slope of the dose-response line (in a quantal assay the slope is an inverse measure of the variance) showed considerable fluctuations in both colonies. These fluctuations must be attributed to unidentified transient environmental causes, which may or may not have been of the type which vary from one animal to the next. The next example shows that, as with genetic factors and environmental factors with persistent effects, a transient environmental factor may profoundly modify the variance of response even if it is applied uniformly throughout the group of animals. Biggers and Claringbold[35] found that the effect of injecting thyroxine was nearly to treble the variance of the response to œstrone. This effect did not persist on ceasing the injection of thyroxine. The administration of methyl-4-thiouracil approximately halved the variance of the response to œstrone, thus acting as a kind of 'uniformity drug'. In the latter case the reversibility of the effect was not tested. Earlier, Langham and Gustavson[36] had shown a similar effect in rats.

A comprehensive review of the role in variance control of uniform factors with transient effects has recently been published by Chance[37], who brings forward many new examples from his own observations. The environmental treatments implicated as having large effects on the variance of the response to a wide range of drugs in several species included temperature, the changing of cages, the size of the cage, the number of animals (female rats) in the cage (two per cage gave the least variance), and an unidentified attribute of the time of day which was found by Wilson[38] to cause changes over a thirty-fold range in the variance of the amount of histamine excreted by guinea pigs.

General Conclusions

The classical view of the causes of biological variation, whether genetic or environmental, is that these causes operate solely in so far as they vary from one member of the population of organisms to the next. We draw the inference from the material which we have reviewed that for the effective control of variation this view must be discarded. When the research worker has taken reasonable measures to ensure that a group of animals enjoy uniform circumstances of genetic background, environmental temperature, humidity and ventilation, diet, bedding, crowding, noise, routine disturbance and handling, etc., he has taken only the first step. He must next inquire whether the particular choice which he has made of genetic background, temperature, humidity, ventilation, diet, etc., is in fact the best for the given species in reducing the variance of the particular characters which he proposes to measure. It is useless to ensure a uniform level of some genetic or environmental factor if the level chosen is such as will in itself inflate the variance of the responses of the animals. There are one or two general principles which can aid his choice, as we have indicated. In general, the conditions which minimize variability seem to be those which promote the general vigour of the colony, whether we are speaking of genetic conditions (for example, heterozygosity) or environmental (for example, temperate as opposed to extreme climatic conditions). But in the end there is no substitute for trial and error. We would add a plea that workers should, if possible, publish their trials and their errors and thus put their experience at the disposal of others faced with similar problems.

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THE ROYAL INSTITUTION AND THE TEACHING OF SCIENCE IN THE NINETEENTH CENTURY*

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THE part played by the Royal Institution in encouraging the teaching of science during the nineteenth century was extensive and of considerable interest.

During the course of his work as clerk of the works there in 1799, Thomas Webster had occasion to supervise the work of men employed in the building and he noticed their frequent inability to do what was required of them. "I proposed then to found a school for mechanics in the house of the Royal Institution in which they should be taught such principles of Science as would be useful in their several occupations".

* Based on discourse delivered at the Royal Institution on May 14. A fuller version will appear in the *Proceedings of the Royal Institution*.

After pointing out that mechanical inventions had not progressed because of the lack of scientific knowledge among working mechanics, Webster gives an outline of his scheme. There would be a preliminary and compulsory course in plane geometry, for which Rossingnol's "Elements of Geometry" was suggested as a text-book; this was to be followed by the principles of projection, for drawing and understanding plans. The students would then proceed to the principles of mechanics and hydrostatics, for which it would be necessary to procure "a little apparatus for making the most useful experiments". At this stage the men were to branch off according to their several professions: the builders to study architecture and those concerned with machinery

and with engines to study higher mathematics, natural philosophy and 'chymistry'. The climax to this most strenuous course was to be a competition open to all for "a certain number to be permitted to attend the Institution gratis". In Webster's eyes, "This would be a powerful incentive to exertion and it would be an honourable testimony in their favour and could scarcely prove of any inconvenience to the Institution".

The scheme would start with a limited number of mechanics being sent by the proprietors of the Institution, and first attention was to be given to the instruction of bricklayers, joiners, tinners, iron-plate workers, "as these were the trades most connected with our improvements at this time". The scheme was accepted by Count Rumford, who was delighted with it, and by the Managers, after Webster had overcome the hesitations of Sir Joseph Banks: "by explaining to him how much the arts would gain by intelligent observation, I overcame a few political scruples which he had".

Some workmen were sent along and the project was launched. It is obvious, however, that from the beginning there was considerable opposition to the whole idea. Later, in 1837, Webster wrote, "I was not unacquainted with the political feelings of this time: but I did not think 'a little learning was a dangerous thing' if *judiciously bestowed*, although without due caution it might be capable of doing more harm than good. My idea was to make *good mechanics*—not to force them, like hotbed plants, out of the sphere in which they were so useful". Indeed, he pointed out the advantage of having the school in the house of the Institution, where the men "would be under the eye of the higher classes, and anything wrong would easily be put a stop to". He tried to disarm criticism by building a separate stone staircase for use by the mechanics, by constructing a gallery in the lecture theatre for those "who for obvious reasons would not like to sit down by their employers", and in other ways. All to no purpose. "But this project for improving mechanics, well intended as it was, which promised to be so useful, and which had already gained for the Institution 'golden opinions' was doomed to be crushed by the timidity (for I shall forbear to speak more harshly) of a few. I was asked rudely (by an individual I shall not name) what I meant by instructing the *lower classes* in science. I was told likewise it was resolved upon, that the plan must be dropped *as quietly as possible*. It was thought to have a dangerous political tendency. I was told that if I persisted I would become a *marked man*". By 1802 Webster had been granted leave of absence by the Managers "for the benefit of his health" and the whole project was abandoned.

Was Webster right in saying that the opposition was political? It could be. Certainly, other mechanics' institutes in different parts of England experienced similar difficulties during their early years. Other reasons have, however, been advanced. It has been said that the reason was largely financial. Alternatively, the point has been raised that the character of the Institution was to give 'fashion to science' rather than 'usefulness to science to poor and rich'.

Although the idea of a mechanics' school died almost at birth, nevertheless there was, in the early years of the Royal Institution, a certain amount of direct and continuous teaching. Both Davy and Faraday were given permission by the Managers to take private pupils in the laboratory, but the whole affair of private lectures was developed by W. T. Brande, who was appointed professor of chemistry and superintendent of the house in 1813. When appointed, he was teaching medical students at a chemical school, and permission was given to transfer these students to the Royal Institution. In 1826, a committee reported very favourably on these private classes. Brande, and later Faraday, gave these lectures in the laboratory at 8 o'clock in the morning and the lecturer received two-thirds of the subscriptions paid by the students. In its report to the Managers, the committee expressed its opinion that "these lectures have been productive of great advantage to the Royal Institution and have greatly raised its character as a school of Chemistry". The committee suggested that the lectures should be given in the theatre and that the laboratory be used for 'extended demonstrations' of the lectures. In this way more people could attend the lectures and more attention would be attracted by them. The lectures would still be given in the morning and so would not clash with the public lectures. The committee further suggested that lectures upon other subjects might be delivered upon similar terms by "Professors of eminence of different sciences" who might be invited "to give lectures to their own Pupils or classes, upon terms of admitting the Members to them gratis".

Brande was also concerned, a few years later, with an attempt to establish a school of practical chemistry at the Royal Institution. During November and December 1843, the Managers were considering a suggestion to start such a school, and Faraday and Brande had reported favourably on the scheme which would have involved special accommodation for some forty pupils. The scheme was finally turned down on the grounds of lack of space. The morning lectures continued, and among those attending were medical students from St. George's Hospital. There is evidence that some difficulty arose because the lectures were considered too technical and not sufficiently popular.

Thus, during the first half of the century many interesting attempts were made to use the facilities of the Institution for direct science teaching.

The Great Exhibition of 1851 gave a considerable impetus to scientific education and within a few years the Royal Institution had become the means of advocating the study of science. In his "Journal", for February 4, 1854, Tyndall writes: "Bence Jones is full of a project for getting seven great guns to lecture upon education". The project of the "seven great guns" soon materialized and seven lectures on science and education were delivered at the Royal Institution during 1854. Two of them are well known: William Whewell, "On the Influence of the History of Science upon Intellectual Education", and Michael Faraday's "Observations on Mental Education". A third lecture, "On the Importance of the Study of Chemistry as a Branch of Education for all Classes" by Daubeny, professor of chemistry and of botany in the University of Oxford, is interesting in several ways: first, in that it reflects the background of the time in its advocacy of scientific study based on faculty-psychology. "A study of this description . . . exercises a distinct set of faculties, just as a new gymnastic exercise calls into play a new set of muscles". Secondly, we have an interesting statement of the claim that a scientific education has advantages

which a classical education has not. Here, Daubeny argues that it is desirable to train and develop at an early age "the faculty of minutely observing, of clearly apprehending and of correctly classifying the objects that present themselves". Further, after the student has left school or university he may not have an opportunity of gaining a sound knowledge of physical science, and, in any case, there are a considerable number of people who cannot stay the course in the present subjects. Finally, Daubeny expresses the desire that the universities should grant full facilities for the study of physical science.

Tyndall's own contribution to the series was "On the Importance of the Study of Physics as a Branch of Education for all Classes". He claims that the study of physics would be an advantage to all. For example, he asks, "Why should Members of Parliament be ignorant of the subjects concerning which they are called upon to legislate? In this land of practical physics, why should they be unable to form an independent opinion upon a physical question?" His own reactions to the lecture are interesting, and n a letter to a friend he writes: "The audience was a fine one, and included many men of eminence. Many Oxford men were present, and Faraday told me that they frowned and looked gruff at the commencement but that every man of them melted before the lecture was concluded".

This series of lectures is important in that they are evidence of an attempt to use the growing prestige of the Royal Institution to break down prejudice against science as a means of education, and to enable that subject to encroach upon the almost universal classical tradition. Some measure of their importance is seen from the discussion of them by Herbert Spencer in his famous work on education.

The story of the Royal Institution and the teaching of science during the latter half of the nineteenth century is mainly the story of the influence of individuals, and here the figure of John Tyndall overshadows all others. He had the advantage of two short periods of practical teaching at Queenwood College, where he taught physics and mathematics. In his teaching he laid stress on the practical side; in science, he developed simple experiments for the boys to do, and in mathematics he taught practical applications of the mathematical principles. From this experience he undoubtedly learnt much that was of value to him later: the need to maintain interest when teaching and the art of devising simple but effective experiments. One of the more important contributions which he made later to the development of science teaching was the effective breaking down of prejudice by his attractive manner.

From his papers we may refer to several examples of his interest in educational questions. In 1866, Dean Farrer, then a master at Harrow, invited Tyndall to speak at the school. Tyndall's manuscripts contain the text of a speech to Harrow masters, delivered on November 15, 1866, in which his theme was the wonder and beauty of ordinary things and the need to introduce boys to the mystery enveloping the universe. "Those who imagine that science tends to destroy this mystery . . . are profoundly in error. It is science which reveals the insoluble nature of the mystery". He illustrates this by experiments dealing with the sensation of touch, with sound, light and crystallization. "All this was very wonderful to me when I first heard of it, and if properly expounded it would be very wonderful to you. No boy of intelligence and imagination could listen to such fairy tales unmoved".

Five years later he was elected a governor of Harrow School on the nomination of the Royal Society and he served in that capacity for twenty-one years, from 1871 until 1892. One can imagine his chief concern at the meetings of governors. In his "Journal", for May 21, 1884, he comments that the land for new buildings was going to cost £14,000 for foundations but that only £21 had been spent in the previous year on laboratories: "Science at Harrow is in a somewhat inanimate condition".

In another manuscript (dated June 4, 1865) entitled "Education and Physics", Tyndall tells us something of his views on the methods of teaching science. Elementary physics should be taught by experimental demonstrations. The facts of all its branches are not merely facts to be stored up in the memory but should also be copiously illustrated by experiments. Further, the relationships of such facts ought to be reasoned upon and connected, the pupils being encouraged to anticipate the connexions and then to check their anticipations by experiment. The questioning of pupils ought to go hand in hand with the performance of the experiments, and this method is preferable to that of formal lectures. The ideal way of teaching chemistry is by way of individual experiments performed by the pupils themselves. "This to my knowledge has been accomplished with great success in private schools". He recognizes, however, that the public schools may not be prepared to undertake the expense of erecting laboratories for this purpose, "though it is expected that the teacher should have a small laboratory for himself to enable him to prepare his demonstrations". He would confine attention to three sciences, elementary physics, chemistry and botany, which he prefers as "agents of discipline" to geology and physiology. Six hours a week should be devoted to science, of which three should be given to physics.

In 1859 the Department of Science and Art tried to secure better teachers of science by starting to award certificates as the result of examination. Tyndall acted as examiner for this as well as for the War Office. In an examination report, dated May 1866, he urges upon candidates and those who prepare them that "a little accurate knowledge is better than a general rambling and indistinct acquaintance with a subject". He returns to his favourite theme: "There is one great fault to be found with some . . . this is a belief that a knowledge of science means the recollection of certain phrases they have read. All teachers of science should remember that the great end of their teaching is to make their pupils *thoughtful*, prompting this thoughtfulness by making them interested and thoroughly conversant with every little step up which they are necessarily taken. The worst teachers are those who give their pupils to commit to memory or repeat to them so many dozen pages of a textbook; the necessary result is a dislike to science".

In his written evidence submitted to the Devonshire Commission, he has several shrewd things to say as a result of his experience as an examiner. In his opinion, a great amount of sound, scientific knowledge had been diffused throughout Britain as a result of the South Kensington Examinations, although teaching appeared to be defective in practical experimentation. The amount of 'cram' was greater than it ought to be and many candidates ought not to have taken the examination. "Their

incapacity must have been known to their teachers, provided the teachers themselves be not utterly incapable".

The Education Act of 1870 inaugurated the setting up of School Boards, and in his papers Tyndall has left a speech which he made just prior to the first elections to these Boards. He deals with some of the problems which are to be faced. Among these he notes, first, the problem of choosing teachers of the right quality. "The mischief done by incompetent teachers is beyond calculation". The next problem is that of text-books. "Almost every whipster imagines he can write a school book, whereas it requires the rarest faculty to write such a book." Here it may be noted that two of his own books, "On Heat" and "On Sound", were used in several public schools. He goes on to say, "The question of books will be one of the most important which the School Boards have to consider". Furthermore, the Boards will also have to determine the subjects to be taught. To the "three R's" he would add an elementary knowledge of some portion of physical science, in which he would include: the elementary facts and principles of chemistry; the nature of air and water and their functions in the human system; the facts and principles of combustion; the elementary facts of light, sound, heat, electricity and magnetism. "With the proper class-books the teacher would have no difficulty in making these things a source of unflagging interest to his boys."

In attempting to summarize the part played by the Royal Institution in the teaching of science during the nineteenth century, one may point out three stages by which the Institution's influence has developed. For nearly the whole of the first half of the century the emphasis, as we have seen, was on attempts at direct teaching. From one point of view, it may be considered that these attempts failed, and yet we may claim that not sufficient attention has been paid to them and that in many ways the Royal Institution pioneered interesting and important experiments of lasting value. The middle of the century saw the attempts to break down prejudice against science as a means of education and to enable it to encroach upon the almost universal classical tradition. Here again it is not unreasonable to say that the Royal Institution played an important part. Finally, it is hoped that sufficient has been mentioned of the influence of John Tyndall to show that, when Webster at the beginning of the century said that "the establishment of the Royal Institution ought to be considered as the commencement of a new era in the history of science in this country", he was a prophet indeed.

CONDUCTION MEASUREMENTS AT LOW TEMPERATURES

A ONE-DAY symposium on measurements of conduction at low temperatures was held by the Low Temperature Group of the Physical Society on April 11 at the Institute of Physics, and was attended by about fifty people. The committee of the Low Temperature Group, under the chairmanship of Dr. P. H. Sykes, arranged the symposium in a form similar to that of previous one-day discussions on the subjects of liquid helium and of low-temperature distillation, since it was felt that meetings of this nature make a valuable contribution towards the discussion and dissemination of recent ideas and results. Such symposia afford an opportunity, especially to younger research workers, of discussing their work informally and in much greater detail than would be possible in the more crowded and formal programme of a large-scale conference. While the time for each paper was restricted to fifteen minutes, almost as much time was allowed for discussion, so that in the course of the day it was possible to consider some thirteen contributions on several aspects of conduction measurements at low temperatures. In view of the informality of the symposium, no detailed record of the proceedings will be published.

The morning session, under the chairmanship of Dr. K. Mendelssohn (Clarendon Laboratory, Oxford), opened with a group of three papers on electrical and thermal conduction in semi-conductors.

Measurements, over the temperature range 2° K.–300° K., of the electrical conductivity and Hall effect in *n*-type indium antimonide with electron concentrations ranging from 2×10^{18} per cm.^{3} down to 5×10^{13} per cm.^{3}, were described by Dr. E. H. Putley (Royal Radar Establishment, Malvern). The ultimate purpose of the work was to estimate the purity of the parent material from the amount of electron scattering by ionized impurities at low temperatures. Because of the very small effective electron mass in indium antimonide, the electron mobilities are very high, rising to maxima as great as 700,000 cm.^{2}/V. sec. below 77° K., and the electron gas becomes degenerate at much lower concentrations than in other semi-conductors so that, for example, the average relaxation times of electrons have to be obtained by integrating exactly over all energies, instead of assuming the usual formulæ for the cases of Fermi-Dirac statistics at high electron densities and of classical statistics. A theoretical calculation of the relaxation time, assuming additive inverse mean free paths for acoustical and impurity scattering, fitted the data at all temperatures, except those for impurity concentrations less than 10^{15} per cm.^{3} at temperatures below 50° K., for which the calculated conductivity exceeded the observed value by a factor of two or three. It is not yet possible to say whether this indicates a defect in the theory of impurity scattering or the presence of some additional scattering. It was pointed out by Dr. Ziman that the conventional use of the Born approximation in the theory of impurity scattering is incorrect; however, a more rigorous phase-shift calculation increases the discrepancy between the observed and calculated conductivities.

Dr. J. A. Carruthers (Clarendon Laboratory, Oxford) described measurements he had made with Dr. J. F. Cochran of the thermal conductivity of a series of *n*-type single crystals of germanium, to which Group 3 impurities had been added in concentrations ranging from 10^{14} per cm.^{3} to 10^{19} per cm.^{3}. The work was carried out between 4·2° K. and 0·2° K. as an extension to lower temperatures of previous results obtained above 2° K. In all the

specimens heat was conducted by the lattice, and although in one of the pure n-type specimens with 10^{18} impurities per cm.^{3} phonons were scattered by the boundaries with 15 per cent specular reflexion, in all the other specimens phonons were scattered by boundaries and by an additional scattering mechanism. The phonon mean free path for this additional mechanism varied with temperature as $T^{0.8}$ in an impurity-band specimen, and varied as $T^{-1.5}$ in highly degenerate specimens, in rough agreement with a theory by Ziman on the scattering of phonons by a quasi-free-hole band with a low density of holes. For the purer specimens, the additional mean free path was approximately constant below 1° K. at values not correlated with the amount of doping impurities.

The aim of a theoretical contribution by Mr. I. C. Pyle and Dr. J. M. Ziman (Cavendish Laboratory, Cambridge) read by the former, on the scattering of phonons by a pair of impurity centres, was to explain the $T^{0.8}$ dependence on temperature of the phonon mean free path in impurity-band germanium, described in the preceding paper. Using a model proposed by Mott for lightly doped semi-conductors, which presupposes some degree of electrical compensation, the mean free path for scattering of phonons by second-order electron transitions between neighbouring pairs of impurity sites was shown to have the required decrease with temperature, and to reach a minimum value near 1° K., but the interaction was not sufficiently strong to explain the experimental results. First-order transitions, involving the complete absorption of a phonon, give a weaker interaction, but this would be increased by the fluctuations in the energies of the bound electronic states due to the random distribution of the impurities.

Electrical conductivity and galvanomagnetic effects in metals formed the subject of the last four contributions to the morning sessions.

Dr. R. W. Powell (National Physical Laboratory) described measurements, made in conjunction with Miss J. A. Nicholls and Mr. R. P. Tye, of the electrical and thermal conductivities to low temperatures of chromium, rhodium, iridium, platinum, rhenium, tungsten, cobalt, nickel, palladium, ruthenium, osmium, silver, and gold. Measurements on the specimens (which were all supplied by Johnson, Matthey and Co., Ltd., with the exception of the cobalt, which was prepared in the Metallurgy Division of the National Physical Laboratory) were also made to higher temperatures, and compared with results from the national laboratories in Canada and Australia. A study was made of the effects of heat treatment on the conducting properties of chromium in the form of a specially prepared electrodeposited tube, and it revealed the existence of an electrical resistance anomaly at about 40° C. after annealing, and of deviations from Matthiessen's rule.

In the first of the three papers on galvanomagnetic effects, Dr. R. T. Webber (U.S. Office of Naval Research) discussed measurements of the longitudinal and transverse electrical magneto-resistance of copper of extremely high purity, in fields up to 100,000 oersteds at 293°, 77°, and 4·2° K. At 4·2° K. the longitudinal magneto-resistance showed a clear-cut saturation, and all the results, except those on transverse magneto-resistance below 50,000 oersteds at 4·2° K., could be fitted to simple two-parameter analytical forms. Since the specimens were annealed polycrystalline wires of diameter greater than ten times the electron mean free path, no size effects were observed, yet the changes in resistance were smaller than those observed by previous workers on specimens in the form of strips of similar size. Kohler's rule was obeyed at 4·2° and 293° K., but not at 77° K. A similar breakdown of Kohler's rule in rhodium at 77° K., described by the next speaker, Dr. B. R. Coles (Imperial College of Science and Technology, London), is attributed to the presence at this temperature of comparable scattering by impurities and by lattice waves, each mechanism being assumed to have a relaxation time with a different lattice-symmetry and dependence on temperature, although, as pointed out by Dr. Ziman, this assumption, which is reasonable, has not been studied in detail. Rhodium also shows a reversal in sign of the Hall coefficient at high magnetic fields, as observed in other metals, and the Hall effect results can be fitted to a simple two-band model, provided one uses values of electron and hole densities which seem unrealistic in any other context. Recent work on the changes in the Hall coefficients of rhodium, palladium, and silver on alloying have shown that these are due, especially at liquid-hydrogen temperatures, not only to changes in the electronic structure, but also in part to alterations in the scattering mechanisms; and a careful interpretation of the results is necessary. In a short contribution on the theory of galvano-magnetism, Mr. F. García-Moliner (Cavendish Laboratory, Cambridge) stressed that, since the expression for the magneto-resistance contains a multiplier which involves the integration of a geometrical factor over the Fermi surface, even slight deviations of the Fermi surface from sphericity can produce large increases in the magneto-resistance. In lithium, the Fermi surface derived by Jones and Zener (with approximately 5 per cent anisotropy) gives the experimental order of magnitude for the magneto-resistance, while surfaces calculated more recently lead to results in disagreement with experiment by two orders of magnitude. The anisotropy also increases the Hall coefficients for the alkali metals by up to 3 per cent and for the noble metals by a rather larger factor sufficient to explain Dr. Coles's results on Hall coefficients.

The afternoon session, under the chairmanship of Dr. F. E. Hoare (University of Leeds), opened with three papers dealing with superconductors. Dr. L. Mackinnon (University of Leeds) reviewed previous ultrasonic conduction measurements in normal and superconducting metals, and described work in co-operation with Mr. A. Myers on absorption of ultrasound in tantalum and mercury. Different absorptions in superconducting and normal tantalum were observed, but the specimen used was not pure enough to show a large effect. Although in mercury, where a very pure specimen is easier to obtain, the effect is much more noticeable, the attenuation of longitudinal waves in the normal metal shows a peculiar behaviour on application of a transverse field. Further experiments on this effect are in progress; an earlier specimen has shown a good, if fortuitous, correlation with recent theories on the energy gap.

Measurements on the thermal conductivity of superconducting lead at temperatures close to 1° K., at which lattice conduction predominates, were described by Dr. H. Montgomery (Atomic Energy Research Establishment, Harwell). It was found that small percentages of alloying material cause only Rayleigh scattering of the phonons, but that plastic deformation greatly reduces the lattice conduction, and it appears that dislocations are distributed at random in annealed material, whereas in strained

material they are assembled in mosaic walls. To overcome the effects of self-annealing at room temperature, measurements on lead alloys strained at 4° K. and on a harder metal, niobium, strained at room temperature, were made by Mr. P. M. Rowell (Clarendon Laboratory, Oxford). The thermal resistivity due to initially straining a niobium specimen varies as the 0·8th power of the strain, and as the niobium and lead alloy specimens are strained progressively, the extra thermal resistivity varies with temperature as $T^{-2\cdot0}$, as expected from the work of Klemens and of van Bueren on dislocations. Pure lead specimens do not show a similar behaviour.

The last three papers dealt with various aspects of scattering by impurities.

The electrical resistance of molybdenum and tungsten specimens irradiated at 77° K. has been measured at helium temperatures by Mr. M. W. Thompson (Atomic Energy Research Establishment, Harwell). Increases in resistance are found to recover after thermal annealing, and activation energies have been determined for the principal recovery processes; these occur at − 170° C. and + 150° C. in molybdenum, and at − 80° C. and + 320° C. in tungsten. It was suggested that recovery in the lower temperature-ranges is due to interstitial atoms being released from traps, whereas that at higher temperatures is due to migration of vacancies. A resistance minimum observed in molybdenum near 10° K. became less pronounced after irradiation and recovered its original form only after annealing at 1,500° C. Miss J. N. Lomer (Clarendon Laboratory, Oxford) described work carried out with Dr. H. M. Rosenberg on a method for determining dislocation densities in α-brass by measurements of lattice thermal conductivity at liquid-helium temperatures. It was found that the dislocation densities introduced by strain are independent of the percentage of zinc alloyed, but depend only on whether the deformation is by single or multiple slip. The dislocation densities reach saturation at strains corresponding to the flattening-out of the stress-strain curves, and these saturation values increase with increasing zinc content. The method is useful for fatigued materials, where the dislocation densities for cyclic stress are found to be the same as for the equivalent tensile stress.

Experiments to determine the thermal resistance due to isotopes in crystals of isotopically enriched lithium fluoride were described by Dr. R. Berman (Clarendon Laboratory, Oxford). The scattering of single phonons can be calculated with reasonable certainty, but it is difficult to deduce the resultant thermal resistance, because the amount of mutual phonon interaction is uncertain. For low concentrations of either lithium-6 or lithium-7 the resistance is two to three times less than for the limit of very strong mutual phonon interactions; it is hoped to measure crystals with high concentrations of isotopes to determine the thermal resistance when mutual interactions are relatively weak. J. A. CARRUTHERS

NEWS and VIEWS

National Physical Laboratory : Dr. J. A. Pople

DR. JOHN ANTHONY POPLE has been appointed superintendent of the newly created Basic Physics Division at the National Physical Laboratory. Dr. Pople, who was born in 1925, graduated from Trinity College, Cambridge, being a 'wrangler' in the Mathematical Tripos. After a short period with the Bristol Aeroplane Co., he returned to Cambridge as a research student under the late Sir John Lennard-Jones. His work in this field led to the award of a Smith Prize in 1950 and election to a fellowship at Trinity College in 1951. Since 1954 he has been a lecturer in mathematics at Cambridge. This year he has been awarded the Marlow Medal of the Faraday Society. Dr. Pople has made theoretical contributions to a number of branches of molecular physics. Working with Lennard-Jones, he took part in the general development of the molecular orbital description of the electronic structure of molecules and has since been concerned with its application to specific problems. In addition, he has worked on the statistical mechanical theory of thermodynamic, dielectric and transport properties of liquids and gases. More recently, he has spent some time in the laboratories of the National Research Council of Canada at Ottawa, working on the interpretation of nuclear magnetic resonance spectra. The present physics programme of the National Physical Laboratory has its origin in the Laboratory's responsibility for measurement of physical constants and has a strong classical flavour; measurement of high pressures, ultrasonics, thermal conductivity and strength of materials are typical items. New fields to which consideration is being given are nuclear magnetics resonance, high polymer physics, and other aspects of molecular physics, including biophysics.

Chemistry at Khartoum : Prof. J. Miller

DR. JOSEPH MILLER, who is at present reader in physical organic chemistry in the University of Western Australia, has been appointed to the chair of chemistry in the University of Khartoum. Prof. Miller is a graduate of University College, London, where he obtained first-class honours in chemistry in 1939. On the outbreak of war, he entered the armed services and obtained a commission in the Royal Engineers. He served throughout the War in chemical warfare units and in various theatres in the Mediterranean, and was discharged in 1946 with the rank of captain. He returned to University College and completed his doctorate in 1948 with a thesis dealing with the hydrolysis of oxime esters. He then joined the staff of the University of Western Australia, where he built up an active research school in physical organic chemistry, the work of the group being directed mainly to the investigation of nucleophilic substitution in aromatic compounds. During 1954, he visited the United States as a Fulbright Visiting Lecturer and spent extensive periods at both the University of California and the University of South Carolina as well as visiting a number of other centres. Prof. Miller, who is married and has three children, proposes to take up his duties at Khartoum at the beginning of the academic year this month.

Brewing Industry Research Foundation : Dr. W. P. K. Findlay

Dr. W. P. K. Findlay has been appointed assistant director of the Brewing Industry Research Foundation, Nutfield, Surrey, in succession to Dr. A. H. Cook, who has recently been appointed director (see *Nature*, 181, 810 ; 1958). Dr. Findlay graduated in botany at the Imperial College of Science and Technology, London, and afterwards gained an Empire Cotton Growing Corporation Fellowship for research at Cambridge and at the Imperial College of Tropical Agriculture, Trinidad. In 1927, he was appointed mycologist at the Forest Products Research Laboratory of the Department of Scientific and Industrial Research, where he now holds the post of senior principal scientific officer. Dr. Findlay has been president of the British Mycological Society, chairman of the Biological Council and president of the Association of Applied Biologists.

Darwin–Wallace Centenary

The Royal Society, in conjunction with the Linnean and Geological Societies, is arranging a conversazione to be held on July 15 to mark the centenary of the reading before the Linnean Society of the paper "On the Tendency of Species to form Varieties", by Charles Darwin and Alfred Russel Wallace. A joint committee of the three Societies has chosen a number of exhibits, some of purely historical interest, others illustrating current research in fields in which Darwin and Wallace worked.

On the following day, July 16, the fifteenth International Zoological Congress opens in London under the presidency of Sir Gavin de Beer, director of the British Museum (Natural History). Sir Julian Huxley will deliver the Darwin–Wallace Memorial Lecture in the Royal Albert Hall during the inaugural meeting of the Congress of Zoology, at 11.30 a.m. on that day ; this Lecture will be open to the public, and seats (2*s*. 6*d*.) are available at the Box Office of the Royal Albert Hall. The record number of nearly two thousand members from fifty-eight countries are attending the Congress, the main theme of which will this year be evolution. All the papers have been printed beforehand so that they can be distributed at the sessions where they are read, and they will be issued, together with records of the discussions, as the Proceedings of the Congress.

Science in the Civil Service

In his chairman's address to the thirteenth annual delegate conference of the Institution of Professional Civil Servants at Hastings on May 19, Mr. E. Hewlett stressed the adverse effect on the structure of the whole of the professional scientific and technical Civil Service of the depression of status of higher grade professional and scientific staff which characterized the Service. Referring as example to the recent appointment of a Comptroller of the Patent Office from the administrative class without qualification in either science or law, Mr. Hewlett said that in 1925 a memorial was addressed to the Board of Trade which, after directing attention to the increasing importance of the Patent Office to our scientific industries, continued : "In modern industry, scientific invention exerts an overwhelming influence, inasmuch as only by invention can new industries be created and dying industries revived. We therefore . . . direct your attention to the desirability of ensuring that the Comptroller of the Patent Office, in addition to possessing the requisite legal knowledge, should, by education and training, be familiar with scientific discovery and development as applicable to manufacture". This statement, said Mr. Hewlett, has even more force to-day, but although the battle had seemed to be won in 1925 when the Institution's journal commented that the fundamental principle that professional, scientific or technical work should be controlled by properly qualified officers was gaining wider acceptance, it seems that the success once achieved might be snatched or whittled away in a few years time.

A motion before the Conference, submitted by the Patent Office Examining Staffs Branch, viewed "with the utmost alarm the continuing encroachment into posts requiring professional qualifications and experience of officers qualified only in an administrative capacity" and registered "its full support of all actions of the National Executive Committee to arrest this practice". The general secretary, Mr. Stanley Mayne, in a wide-ranging speech on May 19, cited numerous other instances of Government failure to deal effectively with scientific matters, and to provide the conditions which would attract to the Civil Service sufficient men and women of the highest scientific and technical qualifications. Public service, said Mr. Mayne, itself is bound to be much of its own reward, but the treatment of some groups was so discouraging as to be a national danger.

Agricultural Research

Replying to an inquiry in the House of Commons on June 16 regarding progress in research into the prevention of losses among lambs from Nematodirus, the Minister of Agriculture, Fisheries and Food, Mr. J. Hare, representing the Lord President of the Council, said that much research bearing directly and indirectly on Nematodirus was in progress all over the world. Fundamental research on the life-history and epidemiology of the parasite was proceeding at several agricultural research institutes in Britain and work on new anthelmintics was being carried out by the pharmaceutical industry. It was too early to assess the bearing of this work in reducing losses from Nematodirus, but Mr. Hare agreed this was an important disease among hill sheep and said he would see that the scale of research devoted to it was adequate.

On June 16, and again on June 19, Mr. Hare was questioned about the work of the Farm Buildings Research Committee. This Committee, set up by the Agricultural Research Council in June 1957, had met three times. A special unit had been established by the Research Council to survey existing buildings and the immediate requirements of farmers. Reports had also been called for from experts in animal physiology, pest infestation and agricultural machinery. In collecting this information the Council was co-operating closely with the Agricultural Land Service, but Mr. Hare said that it would be some time before the results of these inquiries enabled the Committee to formulate research requirements and recommendations to meet them. Two members of the Committee were members of the Royal Institute of British Architects and consultation with the Institute would be arranged when it was likely to be of value.

Aircraft Industry

Replying to questions in the House of Commons on June 16, the Minister of Supply, Mr. Aubrey

Jones, said that about 250,000 persons were employed in all branches of the aircraft industry and on present orders and inquiries it would be about 150,000 in five years time. He had recommended the industry to pursue a policy of diversification, so that problems arising from the contraction of orders for aircraft would be mitigated. His Department was not at present giving financial support to an Earth satellite programme but there were constant consultations with the Lord President of the Council and the Royal Society as to the scientific value of such a programme.

Committee on the Composition of Milk

THE committee on the Composition of Milk, set up in May by the Ministry of Agriculture, Fisheries and Food, held its first meeting on June 27, and decided to invite written evidence from any interested persons or associations. The committee's terms of reference, which include all aspects of milk composition at all stages of production and distribution, are as follows: "To consider the composition of milk sold off farms in the United Kingdom from the standpoint both of human nutrition and animal husbandry, and to recommend any legislative or other changes that may be desirable". The members of the committee are: Dr. J. W. Cook (chairman), Prof. R. G. Baskett, Mr. S. Clifford, Miss R. L. Cohen, Prof. E. L. Crossley, Dr. D. P. Cuthbertson, Dr. P. R. Evans, Mr. G. N. Gould, Prof. W. Holmes, Dr. H. E. Magee, Prof. B. S. Platt, Dr. A. Robertson, Dr. R. Waite, Mr. H. L. Webb and Dr. E. C. Wood. Evidence should be sent not later than October 31 to the Joint Secretaries, Ministry of Agriculture, Fisheries and Food, Great Westminster House (Room 280), Horseferry Road, London, S.W.1.

Causation of Cancer

AN introduction by Prof. A. Haddow, in which he pays tribute to Sir Ernest Kennaway's work, and twenty summaries of work in the different fields of cancer research have recently been published in "Causation of Cancer" (*The British Medical Bulletin*, 14, No. 2; May 1958. Edited by Prof. E. Boyland. Pp. 73–196+4 plates. London: British Council, 1958. 25*s*. net). Haddow summarizes the vast field of the mode of action of chemical carcinogens, and L. A. Elson discusses some dynamic aspects of chemical carcinogens. Cocarcinogenesis is dealt with by M. H. Salaman, and experiments indicating the irreversibility of the changes in the epidermal cell of the mouse after application of carcinogen are described by J. W. Orr, who, from a histologist's point of view, favours the concept of tumourigenesis as being the result of colonies of six or seven adjacent mutated cells. Avian carcinogenesis is reviewed by P. R. Peacock, who directs attention to McGowan's finding of weasel bites as a possible clue to the etiology of fowl tumours. Peacock's observation that cauterization 2–9 days after inoculation with virus will produce tumours anywhere in the fowl seems to offer possibilities of a quantitative estimation of viral antibody formation. F. Bielschowsky and E. S. Horning review the aspects of endocrine carcinogenesis, and H. N. Green describes his immunological theory of cancer. The present knowledge of possible exogenous factors in the causation of lung cancer is summarized by the late Sir Ernest Kennaway and A. J. Lindsay. There are papers by G. M. Bonser, D. B. Clayson and J. W. Jull on chemically induced bladder tumours, the biochemistry of bladder cancer by E. Boyland, on chemically induced liver tumours by J. M. Barnes and R. Schoental, radiation-induced skin tumours by Glücksmann, and radiation-induced tumours of the thyroid gland by I. Doniach. Occupational carcinogenesis is reviewed by M. W. Goldblatt, and A. L. Walpole and M. H. C. Williams describe the carcinogenic hazards encountered in the aromatic amine industry, and the work on the carcinogenicity of different fractions of mineral oil is reported by J. W. Cook, W. Carruthers and D. L. Woodhouse. I. Hieger presents data on the extremely important question of the carcinogenicity of cholesterol. Unfortunately, the table presented seems to indicate that the desiderata for biological examination of carcinogenic substances as described by E. Boyland earlier in the volume have not been fulfilled. W. M. Court-Brown summarizes work on the incidence of leukæmia and radiation, and R. H. Mole deals with the development of radiation leukæmias in animals and the dose-response relationship in radiation carcinogenesis. Many of the summaries contain data and points of view which have been published earlier and in some instances the limited space available has had a severely restricting effect upon the selection of relevant data.

Science Education in South Africa

THE Cape Section of the South African Association for the Advancement of Science has recently conducted experiments on methods for the popularizing of science for the general public and on improvement of science education in schools. First, its Subcommittee on Science Education suggested to the Department of Extra-Mural Studies in the University of Cape Town that it should hold a refresher course for science teachers as one of its vacation courses. In July 1957 courses covering the physical and biological sciences were attended by 160 science teachers and inspectors. Further courses will be held annually, and other South African universities in each of the four provinces are now following suit and holding similar refresher courses. Secondly, in collaboration with the Royal Society of South Africa and the Adult Education section of the Department of Education, Arts and Science, the Association organized a science exhibition in Cape Town in March of this year. Held in the historic eighteenth century Old Supreme Court, twenty-two exhibits on various aspects of scientific research in Cape Town were displayed by some departments of the University as well as the South African Museum, the Royal Observatory and numerous industrial and medical research institutions, and amateur scientists. The main purpose was to present to the general public current research problems in a simple manner, so as to offer the layman the opportunity of becoming more knowledgeable about science and the role of science in society. The newspapers gave full coverage in feature articles and editorials, indicating clearly that such knowledge has become almost a civic duty for an informed democracy in the present age; radio broadcasts were also given along similar lines. All local schools were invited to send senior pupils so as to arouse interest in the young in taking up science as a career. During the five-day period that the exhibition was open, 5,000 people of all ages and races attended. Simultaneously, a series of science films were shown by the Association. As an experiment it was highly successful, and the Association is now planning a similar exhibition on a national scale.

Reports on Radiation Chemistry

The United Kingdom Atomic Energy Authority Research Group has recently published selected abstracts of unclassified reports in the field of radiation chemistry and a bibliography of the published literature up to February 1957, compiled by R. W. Clarke (pp. iv+209. A.E.R.E. *C/R* 1575. Parts 1–6. Supplement 1. London: H.M. Stationery Office, 1957. 28*s*. net). This publication contains 877 references and is divided into six sections, dealing with water and aqueous inorganic systems; organic compounds; gaseous systems; solid systems; biochemistry and radiobiology; and miscellaneous, including colloids, applications of radiation and general reviews. Author and subject indexes are provided. In the individual sections, report abstracts are given first, followed by annotated 'open literature' references. The report references are arranged alphabetically and serially by report reference number, and the other references by author. Recent declassified American reports are included.

Guide to Literature on Atomic Energy

A handy booklet entitled "Guide to U.K.A.E.A. Documents", edited by J. Roland Smith (pp. 20. London: United Kingdom Atomic Energy Authority, 1958), provides a general description of the form in which information concerning the U.K. Atomic Energy Authority is published with special reference to its own publications and of their availability to the public. After explaining that the Authority consists of three Groups—Industrial, Research and Weapons Groups—and a London Office and that scientific and technical information is issued by the Groups independently, the Guide details how unclassified information is published and where unclassified documents may be obtained or consulted. Current reports are listed every month in the "U.K.A.E.A. List of Publications Available to the Public" which the Authority's library at Harwell compiles and issues free of charge. Cumulative lists are also published. Classified documents cannot be made generally available, but in certain circumstances may be accessible to industry, research and government organizations. Finally, the Guide lists and explains the various serial codes and numbering systems used by the Authority for reference to documents and reports. This will be of great value to librarians and cataloguers. For material of more general interest, for example, news of the Authority's activities, lectures delivered by members of the staffs, lists of patents, etc., attention is directed to the monthly bulletin, *Atom*, which is issued by the Director of Public Relations from the London Office (11 Charles Street, S.W.1).

The African Pygmies

A paper entitled "The African Pygmies", by Prof. R. Ruggles Gates, has recently appeared in *Acta Geneticae, Medicae et Gemellologiae* (7, 159; 1958). A detailed discussion of the early literature is given with observations on skin colour, blood groups, and skull and skeletal measurements. It concludes with theories on the origin and relationships of the African Pygmy. The early literature shows that Pygmies occupied a much wider area than at present, which included the Cameroons, Sierra Leone and probably Liberia. Accounts are given of early as well as later European contacts with the tribes. The Pygmies are of ancient origin, with mahogany skin and hairy body. The Negroes have since acquired a black skin by mutation and their bodies have become hairless. The common ancestor of both is thought to be a tall mahogany-skinned race with a hairy body, but this race may now be extinct. The dwarfing of the Pygmy is the result of a single gene mutation of the achondroplastic type. Racial mixture with the Negroes is considered. The Pygmies hunt in the forest, supplying meat to their Negro overlords, who in turn give the Pygmies bananas, this being a symbiotic relationship. However, this is fairly recent, for prior to the introduction of the banana the Pygmies probably fed themselves. Forest Negroes frequently take a Pygmy wife and the children become 'Negroes', but the reverse does not occur; consequently, the Pygmies remain pure except for occasional unofficial mixing. The F_1 hybrids are intermediate in stature and backcross to the Negroes, so becoming absorbed. Measurements show that the Pygmy skull is frequently little smaller than that of the Negro. The ranges apparently overlap, although some Pygmy skulls are very small. The Pygmy skull is very primitive and characteristic, and the Pygmy teeth and jaws are the worst in the human race. This probably has a nutritional basis.

Institute of Physics

At the annual general meeting of the Institute of Physics held in London on July 1, Sir George Thomson (master of Corpus Christi College, Cambridge) was elected president. Dr. R. W. Sillars was elected a vice-president; Dr. J. Taylor, honorary treasurer; and Prof. F. A. Vick, honorary secretary. The two new ordinary members of the Board elected were Dr. A. C. Menzies and Dr. J. Topping. Sir Lawrence Bragg (resident professor and director of the Davy Faraday Laboratory of the Royal Institution) was elected to honorary fellowship in recognition of his eminent work and valuable contributions to knowledge in the field of physics.

Royal Meteorological Society: Officers for 1958–59

The following were recently elected to office in the Royal Meteorological Society: *President*, Prof. P. A. Sheppard; *Vice-Presidents*, Dr. A. W. Brewer, Dr. H. L. Penman, Dr. C. H. B. Priestley and Dr. R. C. Sutcliffe; *Vice-President for Canada*, Mr. R. C. Graham; *Vice-President for Scotland*, Mr. J. R. Atkinson; *Treasurer*, Mr. B. C. V. Oddie; *Secretaries*, Mr. P. J. Meade, Dr. R. S. Scorer, Mr. J. S. Sawyer (*Editor*), Dr. A. G. Forsdyke (*Librarian*).

All-India Congress of Zoology

The Zoological Society of India is organizing the first All-India Congress of Zoology at Calcutta during October 31–November 6. It is the first time that an attempt has been made in India to hold such a conference and to bring together all the zoologists of the country. A number of delegates from foreign countries are expected to attend. The last date for submission of papers to be read before the Congress is August 15. Further information can be obtained from Dr. B. S. Chauhan, Zoological Society of India, 34 Chittaranjan Avenue, Calcutta 12.

The Royal Society and the Nuffield Foundation Commonwealth Bursaries

Awards under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme have been announced as follows: Prof. G. M. Badger,

professor of organic chemistry, University of Adelaide, to assist him to visit Cambridge during January–May 1959, in order to study recent advances in organic chemistry, with special reference to natural products; Prof. J. H. Blaney, professor of mathematics, University College of Ghana, to enable him, during September 1958–January 1959, to have discussions and work with mathematicians at Sydney and Singapore with interests in number theory close to his own; Dr. W. Cochran, lecturer in physics, University of Cambridge, to enable him to travel to Chalk River in order to acquire experience of neutron diffraction techniques, for about a year from August 1958; Mr. A. B. Cribb, lecturer in botany, University of Queensland, to enable him to examine type and other specimens of marine algae, particularly early collections of Australian algae, at the British Museum (Natural History), Kew and other British herbaria, for a year from January 1959; Dr. R. H. Estey, of the Department of Plant Pathology, Macdonald College, McGill University, to assist him to learn new and different techniques in plant pathology and mycology, at Nottingham for two months from July 1958; Prof. T. Gillman, professor of physiology, University of Natal, to enable him to study certain special problems of regeneration of skin, principally at University College, London, during January–July 1959; Dr. P. Gray, lecturer in physical chemistry, University of Leeds, to enable him to study free radical reactions by mass spectrometric and electron-spin resonance techniques at Vancouver, for nine months from September 1958; Prof. H. Kleerekoper, professor of zoology, McMaster University, to enable him to collect and study limnological data from Lake Moneague, Jamaica, in July and August 1958, in order to add to the knowledge of the relationships between biological productivity and the physical and chemical nature of the bottom sediments of a tropical lake; Prof. R. J. Rossiter, professor of biochemistry, University of Western Ontario, to enable him to continue research on the biogenesis of phospholipids, at Canberra for a year from December 1958; Dr. G. Salt, lecturer in zoology, University of Cambridge, to assist him to visit West Pakistan for about six months from October 1958 in order to extend his work on the reactions of insect hosts to ichneumoid parasites and to attempt to apply it to the control of insect pests of crops by means of parasites; Dr. D. A. Scogings, senior lecturer in land surveying, University of Natal, to enable him to travel to University College, London, in July 1958 in order to carry out research in photogrammetry for about six months; Dr. T. B. Teoh, lecturer in pathology, University of Hong Kong, to assist him to study bile thrombi as a means of throwing light on the problems of non-obstructive biliary cirrhosis, at University College Hospital Medical School, London, for a year from September 1958; Dr. C. E. Wright, senior scientific officer, Plant Breeding Station, Loughgall, Northern Ireland, to enable him to study work in New Zealand on blind seed disease of ryegrass for seven months from September 1958.

"Administration and Defence in a Technical Age"

Reference is made in the editorial article under this title in *Nature* of June 28 to the contribution by Mr. R. Blake to "Soldiers and Government". Mr. Blake has pointed out that, although he is in full agreement with what is said by Mr. M. Howard in his introductory essay, he himself is responsible only for the essay on Great Britain.

Announcements

The Rennie Memorial Medal for 1957 of the Royal Australian Chemical Institute has been awarded to Dr. J. H. Bradbury. The H. G. Smith Memorial Medal has been awarded to Dr. K. L. Sutherland for his research work on flotation and allied fields.

The Duke of Northumberland, who was appointed chairman of the Agricultural Research Council some time ago, has now taken office in succession to Lord Rothschild, who retired on June 30 after ten years service as chairman.

The British Association, after sixty-seven years in Burlington House, is moving into a suite of offices in the house belonging to the Royal Society of Arts. From July 14 the address of the Association will be: 18 Adam Street, Adelphi, London, W.C.2. Telephone Trafalgar 5733/4.

The Trustees of the Ciba Foundation, wishing to encourage well-conceived research relevant to basic problems of ageing, invite candidates to submit papers descriptive of work in the field for the fifth and final awards, which are to be made in 1959. Further information can be obtained from Dr. G. E. W. Wolstenholme, Director and Secretary to the Executive Council, Ciba Foundation, 41 Portland Place, London, W.1.

An International Congress on the Modern Educational Treatment of Deafness will be held in the University of Manchester during July 15–23. The Congress has been organized at the request of the Ministry of Education. Further information can be obtained from Jean N. Howarth, Department of Education of the Deaf, The University, Manchester 13.

An informal discussion of the Faraday Society on Free Radical Stabilization will be held in the Department of Chemistry of the University of Sheffield on September 4 and 5. Further particulars can be obtained from Dr. B. Stevens or Dr. H. T. J. Chilton, Department of Chemistry, University of Sheffield.

At the invitation of the Hellenic Society for the Protection of Nature, the Sixth General Assembly of the International Union for Conservation of Nature and Natural Resources will be held jointly with its Seventh Technical Meeting, in Athens, during September 11–19. Further information can be obtained from the International Union for Conservation of Nature and Natural Resources, 31 rue Vautier, Brussels.

The first International Congress in the Aeronautical Sciences, organized by the International Council of the Aeronautical Sciences, will be held in Madrid during September 8–13, when Dr. Theodore von Kármán will preside. The programme is being arranged by committees under the chairmanship of Prof. Maurice Roy, director of the Office National d'Etudes et de Recherches Aeronautiques, Paris; and by Col. A. Perez-Marin, technical secretary-general, Istituto Nacional de Technica Aeronautica, Madrid. British scientists or technologists wishing to attend should apply to Dr. A. M. Ballantyne, 4 Hamilton Place, London, W.1. The address of the Secretariat of the International Council of the Aeronautical Sciences is: Institute of Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

THE FLOW OF BLOOD IN RELATION TO THE VESSEL WALL

A MEETING was held on June 13 to discuss the flow of blood in relation to the vessel wall, at the Charing Cross Hospital Medical School, London, by invitation of the Clinical Research Sub-Committee of the Hospital.

The chairman, Dr. N. C. Lake, welcomed nearly a hundred guests to what was probably the first meeting ever called specifically to discuss 'hæmorheology'. We sometimes regret the invention of still more names for the smaller branches of science; nevertheless, Dr. Lake pointed out, hæmorheology covers a very significant and important field of study, which is really wider than that of hæmodynamics. He briefly outlined a number of problems in surgery and medicine in which the nature of the flow of blood must play a crucial part. (An account of the medical aspects of the discussion will be published elsewhere.)

Dr. G. W. Scott Blair (University of Reading), a rheologist, then read a paper entitled "A Survey of Work on Flow of Blood through Tubes". He pointed out that blood is not far removed from a true (Newtonian) fluid in its behaviour when flowing through narrow tubes, but its deviations from such behaviour are very important. First, any non-spherical particles will tend to align themselves statistically in the direction of flow. Secondly, larger and heavier particles will tend towards the centre of the stream, leaving a layer devoid of particles near the walls. Thirdly, clumping of red cells not only causes them to displace white cells but also tends to increase the 'viscosity' (defined as the ratio shear stress/rate of shear) in the region of low stress, namely, in the centre, in such a way as to flatten the figure of extrusion. This resembles superficially the effects of turbulence; but, although turbulence of various kinds may occur, especially in large vessels, the two phenomena should not be confused. The importance of changes in the relative concentrations of the components of blood resulting from these radial distributions may be expected to be considerable.

Historically, these deviations from the Poiseuille–Hagen law have been studied by two independent and often disconnected groups of workers. The empirical facts concerning the flow of blood have been developed since the time of Poiseuille by a number of authors; in recent decades mainly in Sweden. The theoretical study of these anomalies has accompanied measurements in quite other systems, including paints, clays and plastics. Only recently have the two lines of work converged, to great mutual advantage.

Dr. A. L. Copley, who directs the Research Unit recently set up at Charing Cross Hospital for the study of hæmorheology, then read a paper giving the results of his experiments, *in vitro*, or more correctly, '*non-in-vivo*', since many of the glass surfaces of his viscometers were coated with fibrin, silicone, etc. He used two methods of experiment. In the first, the blood, serum or plasma is contained in a horizontal tube, the central portion of which is narrow, while the two ends are of the same diameter and much wider. The flow is timed over a selected distance in the wider tube, where viscous resistance and surface tension are negligible. The material can be sheared backwards and forwards at different pressures through capillaries of different radii and, if necessary, lengths, while deviations from the fourth-power radius and inverse length laws are measured. The viscometer was checked with a true fluid, sucrose solution, and was found to be satisfactory.

The second apparatus is a tilting-tube viscometer, in which an 'index' of liquid is timed as it slides down the tube at different angles of tilt. Extra pressure can also be applied if desired. Here a correction must be made for surface tension, unless the angles of contact at the two ends of the index are identical, which is seldom the case.

When indexes of blood or its components flow fairly fast down these tilted tubes, a layer is left behind, adhering to the wall, and the thickness of this layer can be calculated. At large angles the sines of which differ but little, samples flowing at the same speeds give adherent layers of a thickness which depends on the angle of tilt.

Preliminary but very encouraging experiments were also described showing significant differences in adherence and in flow-rates when the walls of the tube had been coated with fibrin, silicone, etc. Dr. Copley briefly outlined his theory of the part played by fibrin and fibrinogen in the endothelium.

Dr. P. H. Staple described his work with Dr. Copley on biomicroscopic observations *in vivo* of the plasmatic zone in the capillary beds of frogs and of Syrian and Chinese hamsters. His drawings showed clearly the presence of Poiseuille's 'marginal zone' and, by adding graphite particles and dyestuffs to the flowing material, the authors were able to confirm, for the first time, a number of observations on the effects of rates of flow of blood on the immobile portion of the marginal zone, postulated by Poiseuille more than a century ago.

Many points were raised in discussion on these three papers. Prof. K. Weissenberg stressed the complexity of rheological phenomena and spoke of the causes of different types of turbulence and of flow instability. Other speakers raised points concerning the nature of viscous anomalies in blood, and it was pointed out that it is not possible to infer the presence of adherent layers in full capillaries from the presence of layers which are left behind when an index flows down an inclined tube. Dr. Copley believes, however, from other evidence, that there must be some relationship between adherence of indexes and that in full capillaries.

Two visitors from abroad then addressed the meeting. Prof. M. H. Knisely, of the Department of Anatomy, Medical College of South Carolina, showed a beautiful colour film illustrating the movement of red and white cells in the living animal. Under pathological conditions, the red cells form a sludge which tends to collect along the bottom of the larger vessels. Deep sludges are, of course, well known in post-mortem conditions, but Prof. Knisely's film showed them in anæsthetized animals which were still alive. Observations had also been made on vessels in the eyes of very ill and even dying patients. It was claimed that, in perfect health, red cells show no

agglutination whatever and, indeed, repel one another.

Dr. F. K. Beller, of the University of Tübingen, also read a short communication on micro-coagulation processes on the vessel wall, in which he said that the verification by Drs. Copley and Staple of Poiseuille's claims concerning the plasmatic zone threw much light on hitherto inexplicable results.

The chairman, in closing the meeting, said that it was clear from the vigour of the discussion that the subject had provoked much interest. It was hoped that similar meetings would be arranged in other places where work on the flow of blood is being undertaken.

G. W. Scott Blair

SEDIMENTATION AND OROGENY

THE Fifth International Congress of Sedimentology was held in Geneva and Lausanne during June 2–7, under the joint chairmanship of Prof. Augustin Lombard and Dr. Arnold Bersier, and was attended by more than 160 members from eighteen different countries. About forty-five papers were presented, covering diverse aspects of recent and ancient sedimentation. The central theme of the Congress, however, was the nature and origin of flysch and molasse, and excursions in the Pre-Alps and in the Mittelland were arranged for the study of these deposits in the field.

To many of the Swiss geologists flysch and molasse were clearly terms peculiar to the Alpine orogeny and, despite Marcel Bertrand's wider application of them as early as 1894, never designed for export. Even with this limited usage the gradual application to them of both a lithological and a stratigraphical significance has led to the establishment of such anomalies as "Flysch à faciès molasse" and "Molasse à faciès flysch". Since molasse has also been defined as a rock type (by Lucien Cayeux) the term may be used with a petrographical, facies or stratigraphical significance.

Nevertheless, it was evident that most members of the Congress employed the terms as descriptive of facies and sought criteria whereby the syn-orogenic and post-orogenic sediments of mountain chains other than the Alps might be recognized. Typical of the studies having this end in view were those from Russian contributors describing Upper Carboniferous 'flysch' and Permian 'molasse' from the Urals–Volga oil-bearing region. The most familiar development of the flysch is the regular alternation of shales with poorly sorted micaceous sandstones, often graded and convolute and carrying, at their bases, a variety of cast structures and trace-fossils. It was, of course, pointed out that any or all of these features may be lacking in considerable thicknesses of flysch successions and that none of them is necessarily confined exclusively to syn-orogenic sediments. Nevertheless, there was general agreement that, when present together, they provide an assemblage characteristic of such deposits. The relative proportions of sand and shale in the flysch were regarded as an indication of the distance of the zone of deposition from the rising mountain front.

Opinion differed widely regarding the depth of water in which the flysch was deposited. American communications dealing with modern marine sediments, especially those off the southern Californian coast, made it clear that basins at a depth of 1,000 metres or more are filling with sands interbedded with normal deep-water muds. These were compared with Pliocene basins in California, completely filled with a similar sequence of sediments, where the shales are believed to have served as source beds of petroleum for which the sandstones now provide the reservoirs. The association of Eocene flysch (on the Spanish side of the Pyrenees) with neritic sediments, as described in another communication, however, suggests that depth of water is not necessarily a critical factor. It was noteworthy that the majority of geologists working on modern marine sedimentation accepted turbidity currents as widespread agents of clastic deposition. While the general opinion clearly regarded them as playing an important part in the formation of flysch, doubts were expressed of the need to regard all flysch-type sediments as having originated in the same way.

The change from syn-orogenic to post-orogenic sedimentation must inevitably be gradual and a vertical transition from flysch-type to molasse-type sediments or an alternation of the two facies is likely to be the rule rather than the exception. Confusion arises only where the terms are used in a stratigraphic sense. Molasse, with its massive sequences of poorly sorted sandstones, often strongly current-bedded and associated locally with thick conglomerates (*Nagelfluh*), and with its evidence of intraformational erosion and of cyclical sedimentation, has a characteristic lithology, though in petrographical character its individual units may not differ markedly from those of flysch. Confusion is unfortunately caused by the use of 'macigno' as a petrographical term (following Omalius d'Halloy, Brongniart and Cayeux) for the micaceous sandstone with a mixture of calcareous and argillaceous cementing material which is a common lithology in the molasse. In the Macigno formation of the Apennines the same rock type with beautiful grading, convolutions and sole-markings occurs interbedded with shales in a succession regarded by the Italians as typical flysch.

In the molasse, even more than in the flysch, there is a pronounced zonal distribution of lithologies, with conglomerates bordering the new mountain chains and fine sandstones and shales, often with evaporites, on the external margin of the fore-trough. A number of communications dealing with the petrographical and lithological features of the molasse emphasized the variation to be anticipated between one paralic basin and another and the difficulties to be faced in attempting to reconstruct the history of the final stages of an orogeny from purely sedimentary evidence.

The papers presented at the Congress are to be published as a special number of *Ecologae geologicae Helvetiae*. At the meeting of the International Association of Sedimentology, held during the final session of the Congress, Dr. F. P. Shepard, of the Scripps Institution of Oceanography, was elected president in succession to Prof. C. W. Correns.

J. H. Taylor

ASSOCIATION FOR RADIATION RESEARCH

SOME 170 persons attended the seventh meeting of the Radiation Research Visiting Club held at the Medical Research Council Experimental Radiopathology Research Unit, Hammersmith Hospital, on May 9 and 10. About 100 were present at the open business meeting at which the need for a rather more formal organization was debated under the chairmanship of Prof. F. S. Dainton. This meeting brought to an end the first phase in the existence of the Club, which hitherto has had no rules, no committee, and no subscription, its only existence between meetings having been a list of 'member centres' with some names of individual radiation research workers. The whole responsibility for each meeting has rested on the hosts who have come forward with invitations, and they have been at liberty to arrange the meetings entirely as they wished. The informality of the meetings and the absence of organization appealed to most of those who attended, and many felt very reluctant to start a new scientific society or association. It was generally agreed, however, that the need had become pressing, for two main reasons: the numbers of research workers who had become interested had grown so large that membership on an individual basis was clearly necessary; also, some form of organization was needed to establish and maintain liaison nationally and internationally with bodies having similar or related interests. It was resolved, therefore, that an Association be formed.

The Visiting Club originally sprang from a desire on the part of scientists of different disciplines to meet together in each others' laboratories to discuss topics of mutual interest in the field of radiobiology in which they were working. The meetings of the Club have shown that the subject of radiobiology is broad enough to bring together a group of convenient size. It is probable that other branches of radiation research such as radiation chemistry could do the same. The issue most keenly debated at the recent meeting was whether the organization which the meeting proposed to bring into being should be an Association of people who were meeting primarily on the common ground of radiobiology—with the corollary that similar group organizations would be established for other branches of radiation research—or whether an attempt should be made to establish an organization which would meet the needs of all radiation research workers. As the name of the Association implies, the latter alternative was chosen, and one of the objects of the new Association was defined as being: "To bring together research workers of different disciplines, having a common interest in radiobiology, radiation chemistry and radiation physics".

It was the express wish of those present at this and previous meetings of the Visiting Club that the scientific business of the Association should be "conducted mainly according to the precedent set by meetings of the Radiation Research Visiting Club which have been held before the formation of the Association", and this proviso was incorporated in the constitutional rules which were agreed upon as a minimum operational requirement. From now on, however, the privilege of attending these meetings will be reserved for members of the Association.

Other constitutional rules were decided on which defined the conditions for eligibility to membership—"any person actively interested in the fields covered by the objects of the Association shall be eligible for election to membership"—and the composition of the committee, which everyone agreed should include radiation research workers from varied fields of interest. The first committee, elected for a two-year period, is as follows: chairman, Dr. L. H. Gray; honorary secretary, Miss T. Alper, Experimental Radiopathology Research Unit, Hammersmith Hospital, Ducane Road, London, W.12; honorary treasurer, Dr. C. L. Smith; ordinary members, Prof. A. Charlesby, Prof. F. S. Dainton, Dr. Alma Howard, Dr. J. F. Loutit, Prof. J. S. Mitchell, Dr. Edith Paterson.

The annual subscription was fixed at 10*s*., and it was agreed that anyone who has attended any of the seven meetings of the Radiation Research Visiting Club should qualify for membership without election. Any others wishing to join the Association should be proposed and seconded by members who know them personally. Forms for the purpose may be obtained from the honorary secretary and should be returned by the proposer with accompanying letter of recommendation. It is hoped that the first election of new members will take place at a business meeting which will be held in conjunction with the first scientific meeting of the Association. This will probably take place early in 1959, in Newcastle on Tyne, at the invitation of Prof. J. Weiss. Particulars will be circulated in due course to all who have become members of the Association by the appropriate time.

Most radiation research workers have affiliations with learned societies in their own specialty. The Visiting Club has never duplicated the activities of any learned society, but has set out to bridge the gaps between different disciplines. If, in its larger context, the Association can foster an exchange of knowledge and experience in the same friendly and intimate way as the Club has done, we feel that its future is assured.

L. H. Gray
Tikvah Alper

FRITZ LONDON AWARD

THE fifth International Conference on Low Temperature Physics and Chemistry, held at the University of Wisconsin during August 26–31, 1957, was the occasion of the presentation of the first Fritz London Award. The Award is to be made biennially and carries an honorarium of 1,000 dollars, together with an expense allowance of 500 dollars. The recipient was Dr. N. Kurti, of the Clarendon Laboratory, Oxford, and the texts of the introductory remarks made by Dean F. G. Brickwedde (Pennsylvania State University) and by Prof. J. G. Daunt (Ohio State University), who made the presentation, together with the address entitled "Nuclear Orientation and Nuclear Cooling" delivered by Dr. Kurti, are printed in the March 1958 issue of *Physics Today*. In a preceding article in the same issue,

Dr. J. Wilks (Clarendon Laboratory, Oxford) gives a report of the general proceedings of the conference.

In his remarks, Dean Brickwedde paid tribute to Fritz London for his wide range of contributions to physics and for his philosophical approach to research. He thanked Arthur Little, Inc., for their generosity in sponsoring both the first and second Fritz London Awards, and mentioned that much of the great expansion in cryogenic research since the end of the Second World War was due to this firm because of its manufacture and improvement of the Collins helium cryostat. Prof. Daunt briefly outlined Dr. Kurti's accomplishments in the field of low-temperature physics, referring especially to his investigations at temperatures less than 1° K.

Dr. Kurti, in his address, explained first the essential connexion between nuclear orientation and cryogenics, and then summarized the four basic equilibrium methods of nuclear orientation—magnetic hyperfine structure alignment, magnetic hyperfine structure polarization, external field polarization, and electric hyperfine structure alignment. All four methods have been realized experimentally, the first both at Oxford and Leyden initially in 1951, the second in Oxford about a year later, and the third and fourth in Oak Ridge in 1955 and 1956, respectively. The nuclear orientation experiments had as their chief aim the study of the anisotropy of the gamma-ray emission in a variety of radioactive decay schemes, and by combination of the results with data obtained by conventional nuclear physics methods and by paramagnetic resonance, the decay schemes of some twenty nuclei have been established. Dr. Kurti particularly directed attention to the recent celebrated experiment on parity conservation carried out by E. Ambler, R. W. Haywood, D. D. Hoppes, R. P. Hudson and C. S. Wu at the National Bureau of Standards, pointing out that this had required considerable skill in cryogenics and had brought nuclear orientation methods into the limelight.

Dr. Kurti then turned to consider how nuclear orientation could help in solid state physics, and gave two examples of how, if the decay scheme and hence the gamma-ray anisotropy to be expected is known, the oriented radioactive nuclei may be used as indicators for certain properties. Finally, he dealt in some detail with nuclear cooling, that is, the production of very low temperatures by isentropic demagnetization of polarized nuclei. The idea was first mentioned explicitly in 1933 by C. J. Gorter, and by N. Kurti and E. F. Simon, and the possibilities of attaining the very large values of H_i/T_i (initial magnetic field and temperature) required were discussed by Simon in 1939. The final successful experiments were performed in 1956 (see *Nature*, 178, 450; 1956), and Dr. Kurti described in his address the four steps in a magnetic cooling experiment; the construction of a suitable cryostat for nuclear cooling using magnetically cooled manganous ammonium sulphate, and the results of a series of nuclear demagnetizations all starting from $T_i = 0{\cdot}012°$ K. and from fields, H_i, ranging between 3·5 and 28 kilocersteds. The lowest temperature measured was about 20 microdegrees. It should be possible, Dr. Kurti asserted, to increase the value of H_i/T_i four or five times, thus reducing the nuclear entropy by about 40 per cent from its ideal value. The demagnetization would then lead to a temperature below the nuclear Curie point and the nuclear ordering could be ascertained. Another worth-while problem would be the cooling of other substances into the microdegree temperature range, and it would seem that on theoretical grounds alone there should be no fundamental difficulty. Thus eventually, Dr. Kurti forecast, microdegrees would assume a similar place in cryogenics to that occupied by millidegrees to-day.

S. WEINTROUB

RESEARCH FOR INDUSTRY

UNDER the title "Research for Industry"*, the Department of Scientific and Industrial Research has published a useful summary of the work done by the industrial research associations which the Department assists with grants, covering the fifteen months ended December 30, 1957. "Research for Industry", which corresponds with the summary that formerly occupied about one-third of the Department's annual report, will in future be published separately for each calendar year and generally appears to follow the pattern of its predecessor. Although it gives an interesting picture of the many-sided contribution which the research associations are making to the national life, it does not—and a summary of this character could scarcely be expected to—facilitate assessment of the place of the movement in industry, or its strength or weakness in relation to other institutions, whether from the point of view of research, of education, or of the dissemination of information.

Although most of the research associations issue annual reports, a few points of general interest may be noted to illustrate the wide scope of the movement. The British Baking Industries Research Association, for example, is examining a new milling technique which permits the alteration by mechanical means, to a greater extent than previously, of the protein/starch ratio in the several flour fractions produced, and promises to permit the production from relatively poor quality flour of fractions suited for specialized purposes. The British Boot, Shoe and Allied Trades Research Association has made good progress with new methods of training operatives whereby girls may be fully trained in six weeks. The British Cast Iron Research Association's work on de-phosphorizing foundry iron, which should permit greater use to be made of British ores high in phosphorus for making iron castings, has reached a promising stage.

The British Ceramic Research Association, which in the past few years has made a particular study of the control of dust in those processes in which the health of the operative is at hazard, and has succeeded in controlling dust in the towing and fettling of earthenware on an industrial scale, is now focusing attention on the corresponding problems in the sanitary earthenware and tile industries. The British Coal Utilization Research Association has developed

* Department of Scientific and Industrial Research. Research for Industry: a Summary of work done by the Industrial Research Associations in the Government Scheme, 1956–57. Pp. iv+159. (London: H.M. Stationery Office, 1958.) 7s. 6d. net; 1.35 dollars.

a new design of ash pan for railway locomotives for use with inferior coal, while the British Coke Research Association is seeking the best methods for disposing of liquid effluent from coke-oven plants and establishing the standards of purification required for effluents which are disposed of to rivers and sewers.

The automatic hardening machine designed by the Cutlery Research Council to reduce the labour required for the operation to 25 per cent of that needed for the conventional method represents the Council's first major attempt at mechanization. Machines developed for the classification of fine powders, depending on the opposing action of centrifugal force and inward air-drag, have been used by the Research Association of British Flour-Millers to make cuts in flour at production-rates of commercial interest, giving, for example, a higher protein half of better bread-making quality and the other half of better cake-making quality than the original flour. Large-scale canning trials by the Fruit and Vegetable Canning and Quick Freezing Research Association indicate that the antibiotic, nisin, has potential application in controlling the spoilage of canned vegetables by heat-resistant thermophilic bacteria.

Besides devising apparatus to determine at any time the stage to which glass melting has proceeded, the British Glass Industry Research Association has given much attention to the role of instrumentation and automatic control of furnace conditions, while electronic methods devised by the Hosiery and Allied Trades Research Association have enabled lengths of stockings to be controlled automatically within very close limits. A simple investigation of flow in small open channels by the British Hydromechanics Research Association has permitted the designer to reduce the number of down pipes in a length of building by one-half and has also pointed to a slight modification of the outlet design which can double the capacity of the system.

The British Iron and Steel Research Association has applied the statistical technique of regression analysis to establish correlations between the many factors that affect the performance of blast furnaces, and the British Jute Trade Research Association has developed an anti-corrosive wrapping material for bright steel parts. The Motor Industry Research Association is investigating a promising method of reducing noise in vehicles by damping the vibration of body panels, and the work of the Research Association of British Paint, Colour and Varnish Manufacturers has included the structural features of paint films, the molecular make-up of the medium in film form and the character and disposition of the pigment particles.

An entirely new process for the production of paper pulp from graminaceous raw materials, devised by the British Paper and Board Industry Research Association, gives greatly increased yields, and the Printing, Packaging and Allied Trades Research Association continued its study of the hazards of transport and how packages stand up to them. The British Rayon Research Association has put on the market the warp tension balance, which enables the loom overlooker to control the incidence of repping, and an electronic tensiometer, for the correct setting of yarn spinning and processing machinery; and a study of productivity in the process of mastication and mixing by the Research Association of British Rubber Manufacturers has greatly increased production.

In its methodical tests on models of ocean-going merchant vessels, the British Shipbuilding Research Association is giving much attention to the problem of hull roughness. The Coil Spring Federation Research Organization is studying the effect of variations in manufacture and materials on the fatigue life of heavy suspension springs, and the British Steel Castings Research Association has started a long-range investigation on the factors determining the efficient utilization of oxygen in electric furnace steel-making. The Coal Tar Research Association has given particular attention to factors influencing the purification of naphthalene by fractionation and by crystallization.

AIRFLOW OVER MOUNTAINS

IT has been recognized for many years that regular patterns of motion of a wave-like type may occur in the air flowing over and to the lee of mountain ranges. This seems to have been realized first from the clouds which—given suitable conditions of temperature and humidity—form in the ascending currents of the waves and which are more or less stationary although obviously situated in a strong wind. The rising and falling components of wind in these waves are of importance to aviation as they may cause the aircraft to rise, or more important, descend in a dangerous manner. They have frequently been used by glider pilots as a means of ascent. The wave patterns can occur at considerable distances above and beyond the mountain range responsible and must be distinguished from the irregular turbulent flow set up in the immediate vicinity of the peaks and steep parts of the mountains. The waves are most readily produced by long ranges transverse to the wind.

Much theoretical study has been devoted to the mechanics of the waves in the past twenty years, the most successful theory being due to Dr. R. S. Scorer of the Imperial College of Science and Technology, London. Dr. Scorer's theory has been well verified by the experiences of aircraft pilots and other observations, so that it now appears justifiable for aviation weather forecasters to use it in attempting to predict the occurrence of waves.

Dr. Scorer showed that waves will form only if the vertical gradient of temperature and wind speed in the air to windward of the range are suitable. His theory in fact states that waves will form if the quantity termed l^2, which is given by:

$$\frac{g}{T}\frac{\left(\Gamma + \frac{dT}{dz}\right)}{U^2} - \frac{1}{U}\frac{d^2U}{dz^2}$$

(where T is the absolute temperature, Γ is the numerical value of the dry adiabatic lapse-rate, U is the wind speed, and Z the height), decreases with height. In fact, and fortunately, the difficult second term is of small account compared with the first term, which can be calculated with sufficient accuracy from observations.

From the formula, considering only the first term, it follows that waves are to be expected if the tem-

perature gradient decreases (lapse-rate increasing, in the usual meteorological terminology) with height, or wind speed increases, or there is a suitable combination of both effects.

In Meteorological Report No. 18*, Mr. G. A. Corby of the Meteorological Office describes how Dr. Scorer's theory can be exploited by forecasters when advising pilots on the nature of the airflow over mountains. He gives a number of reports of waves encountered by aircraft, and shows how the occurrence of the waves in question was to be expected from the atmospheric structure. A suitable diagram for computing l^2 is given with instructions for its use in forecasting.

The report also contains diagrams of the flow of air in lee waves computed from the general theory and an account of such effects as the increase in liability to ice formation, given suitable air temperature and humidity, in the waves because the ascent of the air has the effect of lowering the height of the freezing-level.

G. A. Bull

* Air Ministry: Meteorological Office. Meteorological Report No. 18: Air Flow Over Mountains—Notes for Forecasters and Pilots. By G. A. Corby. Pp. ii+53. (London: H.M. Stationery Office, 1957.) 3s. net.

MOUNT STROMLO OBSERVATORY

REPORT FOR 1957

THE annual report of Mount Stromlo Observatory for 1957* deals first with the transfer of the Observatory to the Australian National University on January 3, 1957, when the Commonwealth Observatory of the Department of the Interior officially ceased to exist. All the members of the scientific staff of the Observatory were transferred to the Department of Astronomy of the Research School of Physical Sciences of the Australian National University, the official name of the Observatory then becoming 'Mount Stromlo Observatory'. Arrangements were made not only to safeguard the financial status of the staff but also to protect an area of about 3½ square miles in which the Observatory buildings are situated "from invasion by industry, commerce or any development relating to the growth of the nearby capital city of Canberra".

Following the departure of Dr. R. v. d. R. Woolley in December 1955, Dr. A. R. Hogg assumed the post of acting director of Mount Stromlo Observatory, a position which he retained until Dr. Woolley's successor, Dr. B. J. Bok, took office in March 1957, and on his arrival became head of the newly formed Department of Astronomy at the Australian National University. Tribute is paid to the valuable work accomplished during Dr. Hogg's tenure of office, and on Dr. Bok's arrival he was appointed assistant director.

Tests of the 74-in. mirror by Dr. Hogg, with the assistance of Mr. K. Gottlieb, proved the existence of astigmatism in excess of the maximum permissible amount, and while steps are being taken to remedy this, the telescope during the interim is used for photoelectric, spectrographic and photographic work. Under Dr. Hogg's direction the mirror was successfully aluminized. The 50-in. Melbourne reflector has been overhauled in the Design Department and the workshop. Motorization of the fast motion in right ascension has been completed and provisions have been made for Selsyn repeater systems in both declination and right ascension. Other alterations have been made and an important work plan is well under way to replace the present $f/2$ spherical primary with an $f/4{\cdot}5$ paraboloid and a conventional Cassegrain mirror for the entire system to operate at $f/18$. The 30-in. Reynolds reflector, which continues to be in regular use, is overdue for a complete mechanical and electrical overhaul. Short notes appear on the other instruments, including the 20-in. Catts reflector, the 8-in. $f/1$ Schmidt, and the photographic zenith tube, and considerable space has been devoted to Dr. T. Dunham's plans for a coudé spectrograph on the 74-in. reflector. The spectrograph will be enclosed in a housing with double walls 24 ft. long and 16 ft. wide, and air at constant temperature will circulate between the two layers of the wall, thereby avoiding thermal effects on the instrument.

Among other matters dealt with are observation of artificial Earth satellites. It is emphasized that Mount Stromlo Observatory is not officially involved in the observation of artificial satellites and the names of other institutions and also individuals are referred to in connexion with this work. Nevertheless, *Sputnik I* was kept under observation, and later Dr. A. Przybylski carried out observations of other satellites and did a considerable amount of work on their orbits. He also issued duplicated copies of predicted times of observation which proved to be very reliable.

Eight vacation scholars selected from undergraduate students in physics and mathematics at the Universities of Melbourne, Adelaide, Queensland and Sydney were appointed for the summer months, and each scholar has been assigned as a special assistant to a staff member. These scholars hold weekly colloquia, attend weekly informal discussion meetings, and participate in the night observing, acting as night assistants on the 74-in. reflector during staff vacations. They live in University House, conduct the visitors around during the day-time and participate fully in many other Observatory activities. It is hoped that during 1958 the first appointments will be made to regular scholarships leading to the Ph.D. degree.

Public visits to the Observatory both by day and night have been remarkably popular; to accommodate the great demand for visits by night the Director has instituted a series of monthly visitors' nights, with an average attendance of 150 people, and on these nights most telescopes are open for inspection. Estimates of the number of visitors show that there have been about 3,500 day-time visitors, 500 Wednesday visitors and 1,000 visitors during the seven special evenings. A booklet has been issued which gives information about the Observatory and its work. A list of the names of the twenty-two members of the Observatory staff and a catalogue of papers published during 1957 appear at the end of the report.

* Australian National University: Mount Stromlo Observatory. Annual Report for the Year 1957. Pp. 22. (Canberra: Australian National University, 1958.)

A SIMPLE TECHNIQUE FOR INOCULATING PATHOGENIC BACTERIA ON SUSCEPTIBLE PLANT LEAVES

By M. A. NOUR and J. J. NOUR

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DURING an investigation of virus diseases of 'lubia' (*Dolichos lablab* L.) an extract of the virus-infected leaves was mixed with a small amount of 'Carborundum' (300 mesh) and rubbed on healthy leaves in the normal way. It was observed that when the leaves used as a source of inoculum contained a few lesions of bacterial disease, numerous lesions of the bacterial infection developed on the rubbed leaves. The causal agent was the *Dolichos* strain of *Xanthomonas phaseoli* (Smith) Dowson[1].

Several inoculation tests were made by rubbing either the crude extract (in 10 ml. water) of 10 gm. fresh weight of *Dolichos* leaves infected with *X. phaseoli* or by rubbing a suspension of the pure culture of this pathogen on to healthy leaves of 'lubia' with (+ *C*) or without (− *C*) 'Carborundum' in both cases. The 'undiluted' suspension was obtained by adding 7 ml. distilled water to a 'slope' of 10 ml. yeast-extract agar upon which the pure culture was grown. By scraping and shaking, the yellow turbid suspension was obtained. In another experiment, different dilutions of the crude extract or of a 2–3 day old pure culture suspension were separately mixed with an equal volume of a 1 per cent solution of anhydrous sodium sulphite[2], or with water (as control), and were rubbed on to healthy leaves. This test was made to confirm the earlier observation that a larger number of bacterial spots formed when sodium sulphite, rather than when water, was used with the leaf extract.

In a third series of tests, other related species were rubbed with the crude extract from *Dolichos* leaves heavily infected with *X. phaseoli*, namely, *Phaseolus vulgaris* L., *Canavalia ensiformis* (L.) DC., *Vigna unguiculata* (L.) Walp., *Cajanus cajan* L., *Lupinus termis* Forsk. and *Crotallaria saltiana* Andr.

'Carborundum' in all comparable tests gave a large number of bacterial lesions, many more than in the controls (Table 1). When 'Carborundum' was used, the typical water-soaked lesions appeared after 5–7 days, as compared with 7–10 days when it was not.

The results obtained did not confirm the original observations that sodium sulphite induces the formation of significantly more local lesions than water. Very similar results were obtained with young Domain Sakel cotton plants (*Gossypium barbadense* L.) and a pure culture suspension of *Xanthomonas malvacearum* (Smith) Dowson (Table 2). When 'Carborundum' was used, with both 'lubia' and cotton, a significantly larger number of lesions developed in areas that were mechanically injured than on the apparently undamaged parts.

Table 1. Effect of 'Carborundum' used with Inoculum in Rubbing Half Leaflets of *Dolichos lablab*

Dilution	Lesions per half leaflet			
	With sodium sulphite		With water	
	+ *C*	− *C*	+ *C*	− *C*
1 : 1	584	33	463	31
1 : 2	388	50	250	25
1 : 4	520	44	300	27
1 : 8	300	26	240	16

Table 2. Effect of 'Carborundum' when used with Inoculum in Rubbing Half Leaves of Egyptian Cotton

Dilution	Lesions per half leaf			
	With sodium sulphite		With water	
	Dec. 5	Dec. 9	Dec. 5	Dec. 9
1 : 1	50	340	58	360
1 : 10	131	525	66	355
1 : 10*	3	26	0	23
1 : 100	16	142	51	190

* − *C*.

In the third series, only *D. lablab* showed symptoms of infection. This *Dolichos* strain is specialized enough, therefore, not to cause an infection (or even sub-infection) even when 'Carborundum' is used.

To compare this technique with the standard methods of inoculating bacteria on leaves[3], several tests were done. In one, the first leaves of young *Dolichos* plants were sprayed with a 1 : 1 or 1 : 10 suspension of the bacteria from pure culture, leaving one lot of each in the open and covering the others with bell jars. On another set of first leaves the same dilutions were rubbed, with or without 'Carborundum'. The water-soaked lesions appeared on the leaves treated with 'Carborundum' 4–6 days before those sprayed and covered (Table 3). Again, similar results were obtained when the two methods were applied on young cotton plants, using *X. malvacearum*.

Table 3. Effect* of Spraying as compared with Mechanical Rubbing (+ *C*) of Inoculum on Whole Leaves of *D. lablab*

Dilution	Sprayed		Rubbed
	In bell jar	Open	+ *C*
1 : 1	38	16	> 1,000
1 : 10	14	2	> 1,000

* Average number of lesions per whole first leaf (10 replications) caused by *X. phaseoli*.

This new technique for bacterial inoculation has several advantages. It is highly economical with the inoculum and is simple and easy to apply. Furthermore, the use of high-humidity chambers after inoculation is unnecessary to ensure heavy infections. Another advantage is that the symptoms appear earlier than when the standard spraying method is used. However, the greatest advantage is that the pathogen can be placed exactly where it is required to form lesions of infection.

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BIOCHEMICAL MUTANTS IN BACTERIA WITH IMPAIRED RESPIRATION

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MUTANT strains of staphylococci, with impaired respiratory activities, have been used in the screening of antibiotics to pick out those selectively inhibiting cells with the deficient respiration[1]. These investigations, which formed part of a search for anti-cancer substances, stimulated studies on the production of similar mutations in different species of bacteria.

In *Staphylococcus aureus*, Strain 209, mutations with the respiratory deficiency were induced by ultra-violet radiation[2]. The mutants grew slowly on nutrient agar, producing small colonies which differed from the parent strain in being orange-rose in colour. Their respiration was studied, using Warburg manometry at 37° C. in a medium containing sodium chloride 0·138 *M*, sodium bicarbonate 0·003 *M*, and glucose 0·0555 *M*. Average Q_{O_2} values (µl./hr./mgm. dry weight) were: parent strain 104·0; mutant No. 2 48·0; mutant No. 3 38·1. The addition of 0·012 *M* sodium cyanide inhibited respiration of the parent strain by 86·1 per cent, whereas it inhibited that of mutant No. 2 by 45 per cent and mutant No. 3 by only 14·5 per cent. In other words, the respiratory activity of these biochemical mutants of staphylococci was greatly reduced and was also less sensitive to cyanide, relative to the parent strain[3]. These characteristics of the mutant strains have proved stable, through numerous subcultures, at least for a period of one year.

It is remarkable that the parent culture of staphylococci and the two mutants obtained from it do not differ from each other in their sensitivity to penicillin and to streptomycin, whereas albomycin only inhibits growth of the parent culture and is no longer active against either mutant culture[4]. This is probably related to the fact that albomycin inhibits the growth of bacteria only in the presence of oxygen[4]; perhaps mutant cultures of staphylococci with the impaired respiration no longer possess a specific receptive substance affected by albomycin.

Spectroscopic studies with a Zeiss microspectroscope have shown that, whereas in the parent strain three α bands of cytochromes are distinctly visible (strong b_1 band at 560 mµ, and two smaller bands, *a* at 605 mµ and a_2 at 625 mµ), in both mutant strains band b_1 is no longer visible[3].

Further studies have shown that in *Bacterium coli* and *Bacterium paracoli* biochemical mutations with impaired respiration could also be obtained[3,5]. They are induced by ultra-violet radiation and particularly by urethane, which, as is well known, has a strong carcinogenic action upon the cells of higher animals and inhibits cytochrome electron transport. On nutrient agar, containing 2 per cent urethane, a few rare mutants can be found with the hereditary impairment of respiration among slowly growing colonies of parent culture. These mutants grew slowly on nutrient media without urethane, and have not changed their characteristics in subcultures for a long period of time.

The impairment of respiration in these mutant strains is clearly seen from the following data[3,5]:

	Q_{O_2}
B. coli, parent culture 5383	138·5
B. coli, ultra-violet mutant 8	62·7
B. coli, parent culture 5375	178·0
B. coli, ultra-violet mutant 9	63·7
B. paracoli, parent culture	178·0
B. paracoli, urethane mutant 52–1	42·0
B. paracoli, urethane mutant 52–2	40·5
B. paracoli, ultra-violet mutant 12	36·0
B. paracoli, ultra-violet mutant 15	43·8
B. paracoli, ultra-violet mutant 17	54·2

The respiration of these mutants is also less sensitive to inhibitory action of 0·012 *M* sodium cyanide as compared to their parent strains[3]. Microspectroscopic examination of thick suspensions of living cells of these mutants produced some very instructive results, shown in Fig. 1.

The parent strains of both *B. coli* and *B. paracoli* possessed three distinct α bands, namely, a_2 at 625 mµ, *a* at 605 mµ, and the strong b_1 band at 560 mµ. In all mutant strains the intensity of the *a* band was strongly increased, and in some of them it was shifted from 605 to 600 mµ. Most important of all, however, was the fact that the b_1 band at 560 mµ had disappeared in all mutant cultures, and was

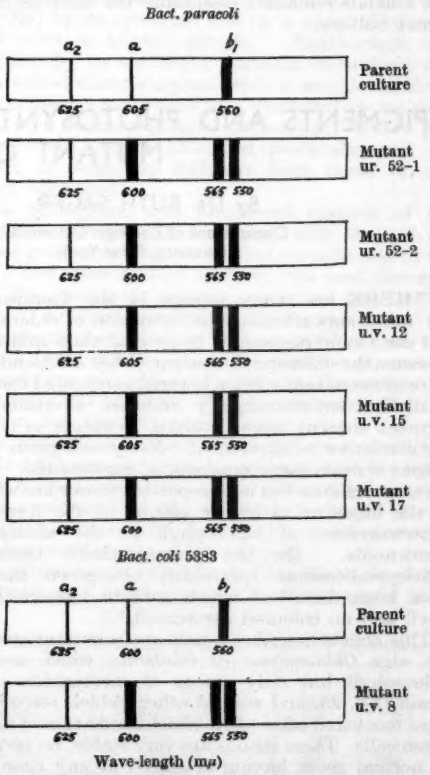

Fig. 1. Cytochrome spectra in parent cultures of *B. coli* and *B. paracoli*, and in six mutations with the impaired respiration obtained from them

actually replaced by two new strong bands, at 550 and 565 mμ. In view of suggestions[6] that the cytochrome b_1 band in *B. coli* results from the fused bands of cytochromes *b* and *c*, the appearance in the mutant with impaired respiration of two new strong bands in the *b* and *c* positions, instead of the characteristic b_1 band of the parent culture, is very remarkable. These characteristic alterations in cytochromes of the mutant cultures of *B. coli* and *B. paracoli* evidently accompany the functional inefficiency of their respiratory system, as it can be judged by the low value of Q_{O_2} and by the decrease of cyanide sensitivity of the oxygen consumption.

Mutant cultures with the impaired respiration in *Bacillus mycoides* (smooth form) were also obtained[5]; they were induced by the combined action of ultraviolet radiation and of urethane. Values of Q_{O_2} at 28° C. were: parent strain 52·8; mutant No. 2 37·0; mutant No. 4 43·3. The respiration of mutant strains was also less sensitive to the inhibition by cyanide as compared to the parent strain—for example, 0·012 *M* sodium cyanide inhibited respiration of the parent strain by 68·5 per cent, mutant No. 2 by 19 per cent, and mutant No. 4 by 30·5 per cent.

Spectroscopic studies showed that the parent culture of *B. mycoides*, in common with many other aerobic spore-forming soil bacteria, possessed the following α bands in its cytochrome spectrum: *a* band at 603 mμ, and two wide bands, almost merging, *b* at 563 mμ, and *c* at 552 mμ. In both mutants of *B. mycoides* with impaired respiration, the *b* band of cytochrome at 563 mμ was no longer visible; the *a* and *c* bands remained essentially the same as in the parent culture.

The mutants in staphylococci, *B. coli* and *B. paracoli* and in *B. mycoides* with impaired respiration, all share the following common features: decreased Q_{O_2} values, and a diminished sensitivity of their respiration to cyanide. However, their respiratory deficiencies are accompanied by different alterations of the cytochrome systems in different bacteria; in staphylococci the cytochrome b_1, and in *B. mycoides* the cytochrome *b*, are no longer visible. In *B. coli* and *B. paracoli* the band of cytochrome b_1 disappears, and two new bands appear in its stead. It is remarkable in this connexion that in the intact ascites tumour cells in mice with impaired respiration[7], spectroscopic study[8] has also revealed a deficiency in cytochrome *b*.

A plea has recently been made for a more rational approach in chemotherapeutic research[9]. Bacterial mutants with impaired respiration seem to represent, in this connexion, very convenient tools for detection of antibiotics and of other substances selectively inhibiting cells with deficient oxidative powers; such substances present interesting therapeutic potentialities, particularly in cancer research.

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PIGMENTS AND PHOTOSYNTHESIS IN A CAROTENOID-DEFICIENT MUTANT OF *CHLAMYDOMONAS*

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THERE are many reports in the literature of mutations affecting the formation of chlorophyll and carotenoid pigments[1]. In general, these mutations decrease the chlorophyll content either independently of, or concomitant with, a lowered carotenoid content. Similarly, environmentally induced alterations of pigment content have involved decreases in chlorophyll relative to carotenoid. Many non-green plant tissues contain large amounts of carotenoids. However, no instance has been reported, to our knowledge, in the algae or in higher plants, of the formation or occurrence of chlorophyll in the absence of carotenoids. (In the photosynthetic bacterium *Rhodopseudomonas spheroides*, blue-green mutants have been described which contain bacteriochlorophyll and no coloured carotenoids[2].)

This article describes a pale-green mutant strain of the alga *Chlamydomonas reinhardi*, which contains chlorophyll but only traces of carotenoids. This strain, No. 95, and several others which resemble it, were recovered after ultra-violet irradiation of normal green cells. These strains are very stable, no reversion to normal green having appeared at any time since the initial isolation, either in stock cultures or in the many litres grown for pigment analysis. Because of the poor growth-rate of these strains, it is probable that reversions to or towards wild type would have a selective advantage, and therefore would have been readily detected had they occurred.

Preliminary examination with the electron microscope[3] of the pale-green mutant has revealed the presence of a chloroplast in which the total amount of lamellar surface is greatly reduced from that of the normal green strain[4]; only a few scattered lamellar membranes are present. In studies using the double-beam spectrophotometer[5] it was determined that the mutant responds to illumination by uptake of carbon dioxide, release of oxygen, and oxidation of respiratory enzymes including cytochromes of the *b* and *f* types. Thus, the pale-green mutant carries out photosynthesis. Its photosynthetic efficiency, on a chlorophyll basis, is greater than that of the wild type. None the less, the mutant dies when grown in the light, whether cultured photosynthetically on a minimal medium or heterotrophically on a medium which supports its growth in the dark.

In view of the many questions as yet unresolved concerning the role of carotenoids in photosynthesis, in the structural organization of the chloroplast lamellæ, and in protection from the lethal effects of

Table 1. Carotenoid Content of Normal Green and Pale-Green Strains of *Chlamydomonas*

	Name of pigment	Absorption maxima in ethanol†			Quantity (mgm./gm. protein)* Normal green (light-grown)	Normal green (dark-grown)	Pale-green (dark-grown)
Hypophasic	*A* (Auroxanthin)	427·5	403	(382)	0·191	—	
	B (Diadinoxanthin)	476	448	(420)	0·299	—	
	C (Flavoxanthin)	453	427·5	(404)	0·105	—	
	D	469	441	(418)	0·105	0·288	
	E	475	446	(423)	0·099	0·352	
	F	475	451	(425)	0·039	—	
	Xanthophyll	474·5	446	(423)	0·303	4·270	
Partially hypophasic	*H*	475	446	(423)	0·178	—	
	I	462	439	(416)	0·063	—	
	J	(475)	445		0·046	—	
Epiphasic	*K*	486	457	(435)	0·296	0·492	
	L	(475)	447	(428)	0·132	—	
	M	436	411	(390)	0·118	—	
	β-Carotene	476	450		3·530	7·930	0·0192
	α-Carotene	473	444		0·181	0·494	0·0067
Total carotenoid					5·69	13·83	0·0259
Total carotenes					4·30	8·92	0·0259
Per cent carotenes					75·8 per cent	64·5 per cent	100 per cent
Per cent β-carotene					62 per cent	57·3 per cent	74·1 per cent

* These values can be converted approximately to mgm./100 gm. dry weight by the factor 25.
† Values in parentheses refer to an inflexion in the spectrum rather than a peak.

light, it was of particular interest to determine the carotenoid content of this pale-green strain. There are no reports in the literature concerning the carotenoids of *Chlamydomonas*, except for those of Moewus on protocrocin and its derivatives[6]. The carotenoids of *Haematococcus*, a closely related genus, have been studied by Tischler[7] and by Goodwin[8]; *b*-carotene and xanthophyll are predominant in the green stages, while the red cysts contain mainly astaxanthin. In addition, there are minor pigments, of which aphanin, aphanizophyll and violaxanthin have been identified.

This article reports the chlorophyll and carotenoid content of the pale-green strain in comparison with that of the normal green strain from which it arose. The major carotenoids were separated by chromatography and identified, and the minor pigments were characterized by their spectra and chromatographic behaviour.

Cells were grown for pigment extraction in liquid medium, containing acetate and inorganic salts[9], and harvested by centrifugation at the end of the logarithmic phase of growth, at densities of 1–5 × 10^6 cells/ml. for the pale-green, and about 1 × 10^7 cells/ml. for the normal green strain. The starting material for carotenoid extraction contained, in the normal green strain grown in light, 152 mgm. protein, in the dark-grown normal green, 35 mgm. protein, and in the pale-green mutant, 240 mgm. protein. Protein was estimated, after acetone extraction, by the biuret reaction and compared with a standard of bovine albumen[10]. Chlorophyll was extracted from washed fresh cells with 85 per cent acetone; optical density was determined in acetone with a Beckman spectrophotometer, and total chlorophyll computed by the method of McKinney[11].

Carotenoids were extracted from fresh frozen cells with methanol, saponified with potassium hydroxide and transferred to hexane. Epiphasic and hypophasic pigments were separated by shaking the hexane solution with 90 per cent methanol. Epiphasic pigments (carotenes) were chromatographed on magnesium oxide and developed with 10 per cent acetone-hexane. Hypophasic pigments (xanthophylls) were chromatographed on calcium hydroxide and developed with 10 per cent acetone-hexane containing 1 per cent ethanol. All pigments were rechromatographed and their spectra taken with a recording spectrophotometer.

b-Carotene was obtained in crystalline form and identified by its spectrum and by a mixed chromatogram with a known sample. Xanthophyll was identified by its spectrum, partition behaviour, and by a mixed chromatogram with a sample obtained from spinach; *a*-carotene was identified by its spectrum and chromatographic behaviour. Other pigments could not be identified positively, and the spectra of some are different from those of any known carotenoid.

The chlorophyll and carotenoid content of the pale-green mutant was compared with that of the normal green strain grown both in the light and in the dark; the same acetate medium was used throughout. The carotenoid pigments recovered are listed in Table 1, in decreasing order of adsorption on the chromatographic columns. Concentrations were calculated from known extinction coefficients, and in the instance of unknown pigments, the extinction coefficients E(1 per cent, 1 cm.) were assumed to be 2,500 at the absorption maximum.

The pale-green mutant was found to contain less than 0·5 per cent of the total carotenoid of the light-grown normal green strain, and less than 0·2 per cent of the carotenoid of the dark-grown normal green. This trace of carotenoid consists of *a*- and *b*-carotene; no other constituents were detected.

No phytoene or phytofluene was found in either pale-green or normal green cells. They would have

Table 2. Chlorophyll Content and Chlorophyll–Carotenoid Ratios of Normal Green and Pale-Green Strains of *Chlamydomonas*

	1 Normal green (light-grown)	2 Normal green (dark-grown)	3 Pale-green (dark-grown)	Ratio 1/3	Ratio 2/3
Chlorophyll conc., moles/gm. protein	$1·55 \times 10^{-4}$	$1·02 \times 10^{-4}$	$8·61 \times 10^{-6}$	18	8·5
Total carotenoid, moles/gm. protein	$1·05 \times 10^{-5}$	$2·58 \times 10^{-5}$	$4·84 \times 10^{-8}$	217	533
Ratio chlorophyll/carotenoid	14·8	3·96	178		
β-Carotene, moles/gm. protein	$6·58 \times 10^{-6}$	$1·48 \times 10^{-5}$	$3·58 \times 10^{-8}$	184	413
Ratio chlorophyll / β-carotene	23·6	6·9	241		

been detected if present in concentrations as low as 10 μgm. per gm. protein. Astacene, which would have been derived from astaxanthin with the extraction procedure used, was also absent.

Light-grown normal green cells were found to contain a number of carotenoid pigments, with *b*-carotene as the major constituent, and others present in small amounts. In dark-grown normal green cells, there was more than twice as much carotenoid present as in light-grown cells, with the bulk of it, too, consisting of *b*-carotene. However, few of the other pigments were found; one component, xanthophyll, was predominant. Thus, it appears that either light or some step in the photosynthetic pathway enhances the formation of a number of minor pigments, possibly at the expense of xanthophyll.

Data on chlorophyll concentration of the two strains are given in Table 2, together with comparisons of chlorophyll/carotenoid ratios. Despite the low chlorophyll content of the pale-green mutant, it is noteworthy that its chlorophyll/carotenoid ratio is still much higher than that of the normal green strain, because of its exceedingly low carotenoid content.

It was estimated[11] that about 60 per cent of the chlorophyll of normal green cells is present as chlorophyll *a*; the rest is *b*. In the pale-green mutant, about 90 per cent of the total is chlorophyll *a*.

The pale-green mutant which was the subject of this study has about 1/15 the chlorophyll and less than 1/200 the carotenoid content of the normal green strain from which it was derived by mutation. This decreased pigment content and high chlorophyll/carotenoid ratio does not interfere with the photosynthetic capacity of the strain. On the contrary, its 'assimilation number' (moles carbon dioxide taken up/mole chlorophyll/sec.) is higher than that of the normal green strain[5], a finding analogous to that reported by Willstater and Stoll for golden varieties of the number of plants[12].

Our findings support the hypothesis that carotenoids are not essential for green plant photosynthesis, except possibly in catalytic amounts. The occurrence of photosynthesis in the apparent absence of carotenoids has also been reported for a blue-green mutant of *Rhodopseudomonas spheroides*[2], which contains bacteriochlorophyll and the colourless carotenoid, phytoene. In discussing this mutant, Calvin[13] suggested that an essential part in photosynthesis, normally played by carotenoids, may be provided in the mutant by "the less conjugated phytoene". Since no phytoene is found in the pale-green *Chlamydomonas* mutant, this hypothesis is at present inapplicable in our material. With respect to the absence of phytoene and phytofluene, the *Chlamydomonas* mutant also differs markedly from the mutants of *Chlorella*[17] and of *Neurospora*[16], and phenocopies obtained with diphenylamine[16] which have been described.

Lynch and French[14] have provided preliminary evidence of the need for *b*-carotene or a related compound in the Hill reaction as carried out by lyophilized broken chloroplast preparations. In their experiments, Hill activity is completely lost after extraction of just a few per cent of the carotenoid. One may question, therefore, how specifically the changes in Hill activity depend upon this small change in carotenoid content, or whether the extraction and recoating process affects the system indirectly.

The pale-green mutant dies when grown in the light either photosynthetically or heterotrophically. This lethal effect of light resembles that described for the blue-green *Rhodopseudomonas* mutant[2]; and the hypothesis that carotenoids protect cells from "photodynamic destruction by chlorophyll"[2] may also apply to the pale-green mutant. On the other hand, the correlated lack of carotenoids and photosensitivity could represent independent results of some more basic deficiency.

The low carotenoid content of the pale-green strain is of interest also in connexion with structural features of the chloroplast as seen with the electron microscope. The lamellar membranes typical of the chloroplasts of all normal green cells including *Chlamydomonas*[4] are found in the pale-green mutant, although their number is much reduced. This finding contrasts with that reported for the yellow mutant of *Chlamydomonas*[15], in which lamellæ do not form in the absence of chlorophyll. When the yellow mutant is brought from dark growing conditions into light, chlorophyll synthesis is initiated and lamellar formation proceeds in parallel[3]. Thus chlorophyll is required for the formation of lamellar membranes, and probably is incorporated as a necessary component into the membranes.

In the pale-green mutant, the reduction of lamellar surface is approximately 20-fold in comparison with the normal green cell, a value which correlates better with the 10- to 20-fold reduction in chlorophyll concentration than with the 200- to 500-fold reduction in carotenoids observed. It is likely, therefore, that carotenoids are not required for the formation of lamellæ, and furthermore, may not represent an essential component of photosynthetically active membranes. In normal green cells, on the other hand, carotenoids probably are incorporated into the membranes, judging from the participation in action spectra of photosynthesis[12] of wavelengths of visible light absorbed principally by carotenoids.

On the question of stoichiometry of constituents of the membranes, it may be noted that the chlorophyll/carotenoid ratio in the pale-green mutant is almost fifty times that in the dark-grown normal green. If the few carotenoid molecules present in the pale-green strain are, in fact, incorporated into the membranes, then their arrangement with respect to the other components must be very different from that in the normal green cells.

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A STEGOLOPHODON FROM SOUTH AFRICA

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DURING an expedition to the Elandsfontein fossil site[1], 10 miles from Hopefield (about 60 miles north-west of Cape Town), we visited the Langebaan Phosphate Quarries (of the African Metals Corporation), which are 10 miles north-north-west of that site. Fossils are known to have been excavated during blasting operations, and on this occasion we were shown some specimens recently recovered by a prospector, Mr. I. S. Brown. This preliminary report deals with only one of these specimens. It was found in Baard's Quarry on the farm Langberg in a phosphate deposit about 15 feet below the surface. Below the sandy surface layer is a layer of phoscrete, below which is a thicker layer of clay and phosphatic nodules. Under this is a 12-in. layer of solid phosphate in which the specimen was found. Details of the geological interpretation of the stratified layers are still awaited.

Other fragments were found with the specimen being recorded, but unfortunately the prospector discarded these and a search for them is still to be undertaken. We are indebted to Mr. A. Coreejes, superintendent of the quarry, for kindly giving the specimen to the South African Museum, Cape Town. Its registered number is S.A.M. 11714.

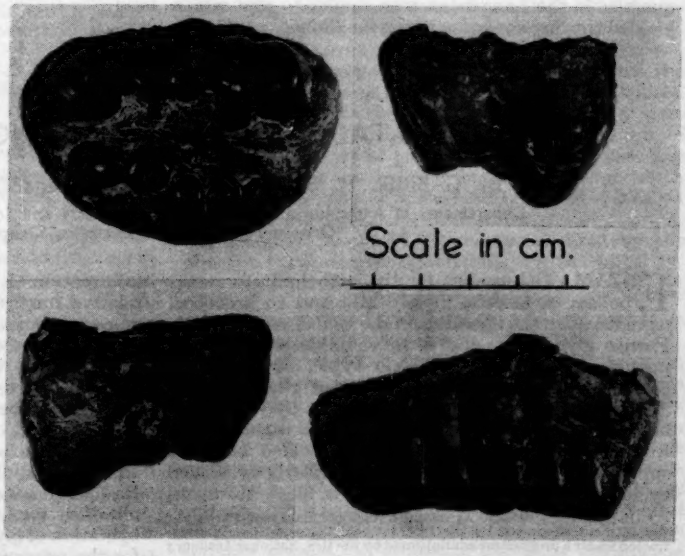
It is a portion of a right upper molar comprising the last two ridges. The hindmost ridge is just in wear and consists of five subequal cones; the two cones on the buccal side are placed somewhat more forward than the other (Fig. 1). Behind and between the two buccal cones there is a fairly large cone, which is in line with the cones in the lingual part of the hind ridge. In turn between it and the central cone of the hind ridge there is a much smaller cone, which together with it represents the talon (Figs. 1 and 2). The posterior margin of the crown is smoothly rounded from side to side, with the base projecting backward slightly more lingually than buccally. The transverse width of the posterior ridge is 62 mm. at base; the height of the almost unworn central cones is 30 mm.

The valley in front of the hindmost ridge is closed in at the bottom. It is filled with cement that extends to the apices of the cones of the hind ridge, and there are two tiny enamel cusps at its lingual entrance (Fig. 3). The cement layer has been lost on the buccal and lingual edges of both ridges as well as on the posterior surface of the crown. There is a natural cleft in the cement limited to the lingual half of the valley between the two ridges (Fig. 1).

The second ridge from behind measures 75 mm. across the base. However, the gingival margin of the crown is incomplete on both sides of the ridge, and the full width of the ridge may have been about 80 mm. The cones of the second ridge are six in number. There are two central cones flanked by two massive cones each of which is imperfectly subdivided into a small central and a larger lateral cone. The two central cones are separated from each other as well as from the cones on each side by clefts that continue to the base of the crown (Fig. 4). The combined width of the two central cones is 18 mm. measured along the occlusal surface, the same as that of each pair of cones on either side. The apices of the dentine cores of all the six cones have just been reached by wear; the ridge is slightly more worn down on the buccal than on the lingual side. The maximal height of the worn ridge is 35 mm. The slope of the buccal edge of the ridge is less steep than that of the lingual edge; this effect is produced by a bulge towards the base of the buccal part of the crown (Fig. 1).

As a whole the second ridge shows a gentle forward transverse convexity. This appearance is reflected by the posterior wedging of the two small cones flanking the central pair of cones. The lingual of the two central cones has a forward bulge, while the posterior surface of the extreme lingual cone exhibits a truncated bulge where it meets the adjoining cone (Fig. 1). The buccal central cone has a small nodular projection on its posterior surface 5 mm. from the occlusal edge.

The roots have broken off, and there is no evidence of the central pits of the cones, which are completely covered by dentine on the upper (root) aspect of the specimen.



It is not possible to state definitely what the serial position of the present specimen is, but because of the stage of wear and the absence of a posterior pressure mark it is considered probable that it is a last molar, M^3 dext.

The Langebaan specimen presents a combination of mastodont and stegodont features. The low, thick-enamelled and squat lateral cones and the presence of an anterior bulge on the median cone simulating an intermediate conule indicate the mastodont affinities. The stegodont features are: the absence of a median cleft in the posterior ridges, the closure of the enamel in the base of the valley, and the arrangement of the cones in transverse rows, although the cones are not quite united into ridges to the degree seen in a true *Stegodon*. There can be no doubt as to the generic assignment of the specimen: it belongs to the genus *Stegolophodon*, which is characterized by this peculiar blending of mastodont and stegodont features[3].

The stegolophodonts represent the most primitive stegodonts. Although originally Osborn[3] included them in the Stegodontinæ, he later erected a new subfamily, the Stegolophodontinæ, for the inclusion of these forms[3]. Simpson[4] again placed them in the Stegodontinæ. In the Indian Siwaliks the single genus *Stegolophodon* ranges from the Chinji, through the Dhok Pathan and the Tatrot into the Pinjor, that is, Lower Pliocene to Lower Pleistocene. It also occurs in the Lower Pleistocene of Borneo[5]. The genus has recently been recorded by Petrocchi from Sahabi in Cyrenaica, North Africa[5,6]. He attributed the fauna in 1941 to the Miocene (?), while in 1943 it is included in the Pliocene; Hopwood and Hollyfield[7] refer the material from the Cyrenaican site to the Pliocene (?). Lower Pleistocene molars from East Africa described as *Archidiskodon planifrons nyanzae* by MacInnes[8] have been regarded by Arambourg[9] as probably belonging to *Stegolophodon*, but the specimens in question do resemble primitive archidiskodont molars so closely as to make it highly improbable for them to represent a stegolophodont.

The faunal remains obtained from nearby phosphate quarries in the Langebaan area similar to that which yielded the *Stegolophodon* represent *Rhinoceros*, *Equus*, *Sivatherium*, antelopes cf. *Oreotragus*, cf. *Damaliscus* and cf. *Redunca*, and a large buffalo, cf. *Homoioceras*. All these are essentially Pleistocene types but they are derived from limestone deposits while the *Stegolophodon* was found in the phosphate layer at a deeper level. It is probable that the limestone deposits are Upper Pleistocene whereas the phosphate layer is Middle or Lower Pleistocene. Therefore, it is most likely that the South African *Stegolophodon* is Middle Pleistocene in age.

The Langebaan stegolophodont is widely different from the bunolophodont mastodont described from the higher terrace (60–80 feet) of the Vaal River at Waldeck's Plant near Kimberley by Beck[10] and by Fraas[11]. The latter is still the only mastodont ever to have been described from South Africa.

The fossil molar fragment described in the present article provides the first evidence for the occurrence of the genus *Stegolophodon* in Southern Africa.

Because of the fragmentary nature and uncertain serial position of the Langebaan *Stegolophodon* molar, we prefer to abstain from a specific determination. Until more complete specimens have been obtained the stegolophodont of South Africa may be recorded as *Stegolophodon* sp.

One of us (D. A. H.) is visiting South Africa on a grant from the Netherlands Organization for Pure Research (Z.W.O.). The other (R. S.) is indebted to the South African Council for Scientific and Industrial Research and the Wenner-Gren Foundation for Anthropological Research, New York, for generous grants for research at the Hopefield site.

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GLUCOSE CATABOLISM IN THE AMERICAN COCKROACH

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ENZYMATIC studies on the carbohydrate metabolism in insects, mostly flies and cockroaches, have revealed the operation of the Embden–Meyerhof–Parnas glycolysis[1], and a direct oxidative pathway, possibly of the pentose cycle type[2], as the major catabolic routes for the utilization of glucose in the insects. Recent tracer studies reported by Wintering-ham *et al.*[3], using acetate labelled with carbon-14, as well as other enzymatic work[4], provided evidence supporting the occurrence of the tricarboxylic acid cycle for the metabolism of acetate in flies. However, information is not yet available concerning the relative importance of these catabolic pathways of glucose in intact insects.

In this laboratory, time-course studies on the utilization by intact cockroaches (*Periplaneta americana*) of glucose specifically labelled with carbon-14 have been carried out. Respiratory carbon dioxide was collected during prescribed time intervals from the cockroaches metabolizing the labelled glucose administered by means of injection techniques[5]. Radioactive assay of the carbon dioxide samples so obtained provided confirmatory evidence for the operation of glycolysis and a direct oxidative pathway for the primary breakdown of glucose in this species.

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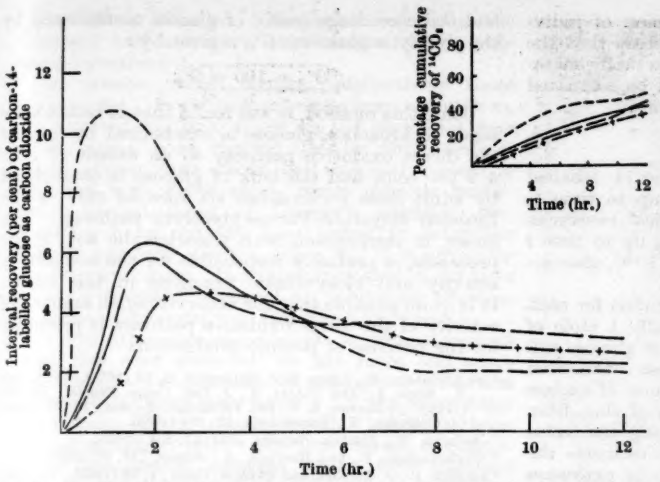

Fig. 1. Interval recovery of carbon-14 in expired carbon dioxide from *P. americana* metabolizing glucose labelled with carbon-14: ——, glucose-1-^{14}C; — —, glucose-2-^{14}C; - - -, glucose-3(4)-^{14}C; — + —, glucose-6-^{14}C

It was estimated that the latter pathway is responsible for the metabolism of only 4–9 per cent of the glucose administered in the intact cockroaches.

Essentially, the time-course experiments were carried out in a manner similar to that reported by Wang *et al.*[6] for the study of glucose metabolism in yeast. Usually 32 cockroaches, fasted for 12 hr. and divided into four groups having equal total body-weight, were used in each series of experiments. To each cockroach in the group was administered a solution of the labelled glucose, having a concentration of 250 mgm. per ml. and a specific activity of 1·8 μc./m.mole. The dose used was generally 23 μl. per gm. of cockroach. Glucoses-1,2,3(4) and 6 labelled with carbon-14 were used in each experiment (obtained through the co-operation of Dr. Isbell of the National Bureau of Standards, except in the case of glucose-3(4)-^{14}C, which was prepared in this laboratory according to the method of Wood *et al.*[7]). The cockroaches used in the present experiments were six-month adults, furnished by Dr. A. Mallis, of the Gulf Research Co. of Pittsburgh, Pennsylvania, through Prof. P. O. Ritcher, of Oregon State College. Males were used exclusively on account of their strikingly high respiratory-rate (ref. 1c). After the injection of the substrates, the cockroaches were kept in metabolic bottles maintained at 28° C., respiratory carbon dioxide being collected and assayed for carbon-14 by conventional techniques.

The interval radiochemical recoveries of substrate activity in the respiratory carbon dioxide from cockroaches metabolizing the specifically labelled glucose obtained in a typical experiment are given in Fig. 1. Satisfactory reproducibility was observed upon completion of scores of identical experiments. It is evident that the Embden–Meyerhof–Parnas glycolysis, in conjunction with pyruvate decarboxylation, is the major pathway for primary breakdown of glucose as indicated by the rapid recovery of the bulk of C-3(4) of glucose in carbon dioxide. The acetate produced in the foregoing processes is probably metabolized further by the conventional tricarboxylic cyclic process[8]. This is also indicated by the finding that, soon after the phase of rapid conversion of C-3(4) of glucose to carbon dioxide, C-2 of glucose began to appear in carbon dioxide at a rate constantly higher than that of C-6 until 3 hr. after the injection. The finding is understandable if one supposes that C-2 and C-6 of glucose correspond to the carboxyl and methyl carbon atoms of acetate respectively. Operation of the conventional tricarboxylic acid cyclic processes would then call for a preferential combustion of the carboxyl carbon of acetate to carbon dioxide in the early stages. That an alternate pathway is operating in the cockroaches for the primary breakdown of glucose is shown by the observed preferential recovery of C-1 of glucose in carbon dioxide as compared with that of C-6. In view of the reported activity of glucose-6-phosphate dehydrogenase and 6-phosphogluconate dehydrogenase in insects[9], it is reasonable to believe that the alternate pathway observed here in our cockroach experiments is of the phosphogluconate decarboxylation type, although the extent of the operation of the pentose cycle for the metabolism of pentoses cannot be determined in the present work.

The cumulative percentage radiochemical recoveries of substrate activity in carbon dioxide from cockroaches metabolizing glucose-1,2,3(4) and 6-^{14}C, designated respectively as G_1, G_2, $G_{3(4)}$ and G_6, are given in the insert of Fig. 1. The estimation of the individual catabolic pathways of glucose in the cockroaches were made using the method of Wang *et al.*[6]. Bearing in mind the assumptions made in the original paper[6], the extent of operation of individual catabolic pathways for the glucose administered can be expressed in the following equations:

Percentage (min.) of glucose metabolized by the phosphogluconate decarboxylation, designated G_p, is given by:

$$G_p = G'_1 - G'_6 \qquad (1)$$

where G'_1 and G'_6 represent percentage cumulative radiochemical recoveries of substrate activity in carbon dioxide from cockroaches metabolizing glucose-1-^{14}C and glucose-6-^{14}C respectively, at the time the glucose administered has been completely catabolized in the system. In the present work, the latter time was chosen as 6 hr., since at that moment the rate of recovery of C-3(4) of glucose in carbon dioxide has decreased to a much lower but steady level which reflects the exhaustion of the readily available labelled glucose in the insect.

Percentage (max.) of glucose metabolized by the glycolytic pathway, designated G_e, is given by:

$$G_e = 100 - G_p \qquad (2)$$

since it was assumed that there are only two pathways functioning in this organism.

It is understood, however, that in the foregoing equation it is assumed that the labelled glucose administered to the cockroaches was completely catabolized degradatively to its breakdown products. On the other hand, a portion of the glucose administered may have been incorporated into polysaccharides or other fractions containing glucose in its entirety. This would then necessitate an experimental determination of the amount of the labelled glucose actually engaged in catabolic functions during the

experimental period before the estimation of individual pathways can be made. It appears that the fraction of carbon-14 labelled glucose actually metabolized degradatively in the insect can be estimated approximately by the following equation:

$$G_t = (G_1 - G_6) + G_{3(4)} \quad (3)$$

where G_t is the percentage of carbon-14 labelled glucose engaged in insect catabolism up to time t; G_1, G_6, $G_{3(4)}$ are percentage radiochemical recoveries of substrate activity in carbon dioxide up to time t from cockroaches metabolizing glucose-1-^{14}C, glucose-6-^{14}C, and glucose-3(4)-^{14}C respectively.

Equation 3 is derived from the view that for each mole of glucose catabolized glycolytically 1 mole of carbon dioxide from either C-3 or C-4 of glucose will be produced, and for each mole of glucose catabolized via the direct oxidative pathway 1 mole of carbon dioxide from C-1 of glucose in excess of that from C-6 of glucose will be produced. Using the value of G_t so obtained, it is then possible to estimate the extent of operation of individual catabolic pathways of glucose as follows:

Percentage (max.) of glucose metabolized by the phosphogluconate decarboxylation, G'_p, is given by:

$$G'_p = \frac{(G_1 - G_6) \times 100}{G_t} \quad (4)$$

and the percentage (min.) of glucose metabolized by the glycolytic pathway, G'_g, is given by:

$$G'_g = 100 - G'_p \quad (5)$$

Using this method, it was found that in intact male adult cockroaches, glucose is catabolized by way of the direct oxidative pathway to an extent of only 4–9 per cent, and the bulk of glucose is catabolized by adult male cockroaches six months old via the Embden–Meyerhof–Parnas glycolytic pathway. The latter, in conjunction with tricarboxylic acid cyclic processes, is probably responsible for the respiratory activity and biosynthetic functions in this insect. It is quite possible that the observed small amount of activity of the direct oxidative pathway is primarily for the purpose of pentose production.

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EXPERIMENTAL ALLERGIC ENCEPHALOMYELITIS

Production of Experimental Allergic Encephalomyelitis in Guinea Pigs with Fractions isolated from Bovine Spinal Cord and Killed Tubercle Bacilli

FOR many years, allergic encephalomyelitis has been produced experimentally in animals by injection of a mixture containing whole brain or cord and whole killed tubercle bacilli. Many attempts have been made to fractionate the active material in nerve tissue, but tests on these fractions have always been carried out with whole killed tubercle bacilli in the adjuvant mixture. Recently, Colover and Consden[1] have reported that certain residues from tubercle bacilli possessed the same ability as the whole organism to sensitize the animal to the encephalitogenic effects of brain. Their tests were run on tubercle bacillus fractions combined with whole brain.

With Dr. Colover's co-operation, 'purified' fractions have been exchanged and combinations of cord and tubercle bacillus fractions have been tested in each laboratory. The results of our tests on these fractions are reported here.

The cord fraction which Colover tested in his laboratory was a collagen-like protein of molecular weight around 40,000, which has been found to be homogeneous by physico-chemical methods[2]. By a quantitative assay technique developed in our laboratory[3], it has been found to be two to three times as active as whole lyophilized bovine cord. Because of the high state of purity of the compound and its probable concentration in whole cord (1·6 per cent was isolated) it was concluded either that its activity was attenuated or that this compound alone could not account for the entire activity of whole lyophilized cord. Consequently, other less drastic extraction methods were investigated in an attempt to isolate a fraction with higher specific activity than the collagen-like protein.

The fraction used in our tests with Colover's tubercle bacillus fractions was a cold 5 per cent potassium chloride extract of partially defatted bovine spinal cord, which was approximately ten times as active as whole lyophilized cord when compared on a dry-weight basis, and thus five times as active as the collagen-like protein. It consisted mainly of protein with 1–2 per cent carbohydrate and no detectable

Table 1. Allergic Encephalomyelitic Activity of 'Purified' Fractions from Bovine Cord and Tubercle Bacillus

Tubercle bacillus fraction	Disease index* mean ± standard error
None	0 ± 0
0·25 mgm. whole *H37RV*†	7·9 ± 1·2
	8·4 ± 0·9
0·1 mgm. whole *H37RV*‡	7·1 ± 1·1
0·025 mgm. whole *H37RV*†	4·8 ± 1·3
0·1 mgm. Colover's 'crude' fraction	6·9 ± 1·4
0·02 mgm. Colover's 'crude' fraction	7·4 ± 1·8
0·1 mgm. Colover's 'purified' fraction (1/172)	3·2 ± 1·0
0·02 mgm. Colover's 'purified' fraction (1/172)	8·0 ± 1·0

The cord fraction was 0·02 mgm. *C–2–P* (5 per cent potassium chloride extract of partially defatted bovine spinal cord throughout).

* The disease index is a numerical evaluation of the severity of the disease reaction, based on combined clinical and histological data and the presence or absence of lipæmia. The scale is from 0 (no disease) to 10 (maximum reaction). The average of ten animals injected simultaneously is used for the disease index of a given weight of material. Maximum values for most fractions vary from 7 to 9, with a standard error of the mean of ± 1.

† Air dried. Kindly supplied by Dr. A. G. Karlson, Mayo Clinic.

‡ Lyophilized. Kindly supplied by Dr. P. Y. Paterson, New York University, and National Institute of Allergy and Infectious Diseases, Laboratory of Immunology.

lipid. More detailed information regarding the chemistry and activity of this fraction will be published elsewhere[3,4].

The results, which confirm qualitatively those reported by Colover (see following communication), are reported in Table 1. With the particular dose of the spinal cord fraction used in these tests it would appear that about half-maximal disease is produced with 0·025 mgm. whole tubercle bacilli. Small enough doses of Colover's bacillary preparations have not yet been tested to determine their 50 per cent effective doses, but it is obviously less than 0·02 mgm. It is interesting that in our tests with his 'purified' material an inhibitory effect is observed with a relatively large dose (0·1 mgm.).

As our experience accumulates in testing various brain and cord fractions, we are more and more impressed by the necessity of testing every fraction at several different dose-levels. To our knowledge, the activity of the tubercle bacillus has never been studied quantitatively. For this reason, a quantitative comparison between these two fractions and the whole tubercle bacilli cannot be made. Freund (personal communication) found that with a dose of whole brain giving maximal reaction, 0·016 mgm. killed tubercle bacillus was near the lower limit of effectiveness. Our experiments indicate a similar lower level (0·02 mgm. killed tubercle bacilli).

The experiments reported are preliminary in the sense that the fractions tested, with the exception of the collagen-like protein from bovine cord, are not pure compounds. The crucial experiment remains to be done—the production of the disease with two pure chemical compounds. The present results indicate that this goal will eventually be realized, since it has been shown that neither whole nerve tissue nor whole tubercle bacillus is an absolute requirement for the production of allergic encephalomyelitis.

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Experimental Allergic Encephalomyelitis induced with Combined 'Purified' Spinal Cord and Bacillary Fractions

IT has previously been reported by Colover and Consden[1] that residues made from heat-killed human tubercle bacilli which had been subjected to serial chemical procedures still retained the capacity to produce experimental allergic encephalomyelitis in guinea pigs when combined with homologous brain by the method (method 1, Table 1) described by Colover[2]. As a result of the kindness of Dr. Marian W. Kies, of the U.S. National Institute of Mental Health, a sample of 'collagen-like protein II-*B*'[3] prepared from bovine spinal cord by Dr. E. Roboz was made available for trial with this bacillary residue (1/172)[1]. An emulsion was made so that each ml. contained: 0·5 mgm. bacillary residue 1/172; 0·4 ml. 'Bayol *F*'; 0·2 ml. 'Falba'; 0·4 ml. normal saline; 0·2 mgm. collagen-like protein II-*B*. This latter fraction was used as a substitute for the 50 mgm. of heated brain emulsion previously used[1]. Eight guinea pigs were injected with 1 ml. of emulsion at weekly intervals between the scapulæ intramuscularly, each animal receiving four injections. Three became severely paralysed and died just before the thirtieth day; the remainder were killed on the fortieth day. On histological examination five animals showed the typical lesions of experimental allergic encephalomyelitis, and another animal showed a large intradural granuloma. The extent of the lesions was less than when 50 mgm. of heated brain emulsion per ml. were used as the brain factor. Six control animals were similarly treated except for the omission of the bacillary factor from the injected material. Three were killed at 30 days and three at 40 days. None showed neurological signs, but one showed an isolated focus of microglial reaction in one cerebral hemisphere histologically.

Table 1

Method (see text)	Tubercle bacillus fraction	Central nervous fraction	Result*
1	2 mgm. Residue 1/172 (ref. 1)	200 mgm. whole guinea pig brain	7/11
1	2 mgm. Wax *D* Canetti†	200 mgm. whole guinea pig brain	1/6
1	2 mgm. Residue 1/172	0·8 mgm. collagen-like bovine spinal cord protein (II-*B*) (ref. 3)	5/8 (40 days)
2	0·1 mgm. Purified residue 1/172	16 mgm. guinea pig brain	5/5
2	0·1 mgm. Wax *D* Canetti	16 mgm. guinea pig brain	4/5
2	1 mgm. Wax *D* Canetti	0·2 mgm. II-*B*	5/6
2	1 mgm. Wax *D* Canetti	0·2 mgm. 5 per cent potassium chloride extract of bovine spinal cord‡	6/6

* Numerator, number of animals with experimental allergic encephalitis; denominator, number of animals in the experiment.
† This material gave different results in methods 1 and 2.
‡ Kindly prepared and supplied by Dr. E. Roboz.

Kies, Alvord and Roboz (see previous communication), using a different technique, mixed a sample of the same purified bacillary residue prepared by Colover and Consden with another bovine spinal cord protein prepared by extracting the cord with 5 per cent potassium chloride after preliminary defatting, and have found this mixture was active in producing experimental allergic encephalomyelitis in guinea pigs.

Previous attempts by Colover and Consden[1], Colover[3,4], were negative when various wax fractions of tubercle bacilli were combined with homologous whole brain. Positive results with wax fractions had been obtained[5,6], and in view of this a further trial was made with wax *D* Canetti prepared by Dr. J. Asselineau and kindly supplied by Dr. E. Lederer, containing similar components to those present in the residue 1/172 (Lederer, E., personal com-

munication). The method of injection (method 2, Table 1) differed from that described above (method 1) in that single injections of 0·2 ml. of the following emulsions were injected into the dorsum of the hind foot of guinea pigs: 1 or 0·1 mgm. bacillary fraction; 0·085 ml. 'Bayol *F*'; 0·015 mgm. 'Arlacel *A*'; 0·1 ml. saline; 16 mgm. of whole guinea pig brain or 0·2 mgm. bovine spinal cord fraction.

Table 1 shows that by this method homologous whole brain and both bovine spinal cord fractions were effective with wax *D* Canetti.

The results reported here and by Kies, Roboz and Alvord in the previous communication confirm that experimental allergic encephalomyelitis can be produced in guinea pigs by emulsions containing only relatively small fractions of acid-fast bacilli and central nervous tissue, and show that either of two constituents of tubercle bacilli (residue 1/172 and wax *D* Canetti) mixed with either of two bovine spinal cord protein fractions can be effective.

I would like to thank the Medical Research Council for a grant towards this work.

Note added in proof. Since the submission of this paper it has been found that 1 mgm. of chromatographically pure wax *D* Canetti (E. Lederer), which is a pure compound, combined with fraction II-*B* produces a high incidence of experimental allergic encephalitis in guinea pigs.

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SYNTHETIC POLYPEPTIDE SUBSTITUTES FOR GELATIN IN PHOTOGRAPHIC EMULSIONS AND OBSERVATIONS ON GELATION

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THE synthesis of water-soluble ampholytic polypeptides has been undertaken with the view of simulating those properties of gelatin which are involved in the preparation of photographic emulsions. Two attributes will be discussed here. The first, of specialized interest, is the ability to promote the growth of flat, well-shaped silver halide grains during the process of physical ripening. Many of the colloids which have been proposed as substitutes for gelatin, for example polyvinyl alcohol, are not able to do this. It seemed at one time that a polypeptide structure was obligatory; but recently, it has been found that certain polyethylene oxides are effective[1]. It is now shown that the required kind of grain-growth can be achieved with synthetic polypeptides. The work also permits some observations on the other important property of gelatin, one which is of wider interest, namely, gelation. The two attributes under consideration, control of grain-growth and gelation, are not necessarily so diverse in origin as would at first appear, because the former probably relies partly on those intermolecular links which are formed, to a much greater extent, in a gel.

Ampholytic polypeptides have been synthesized by a method, now well known, in the following two stages. (1) Co-polymerization of Leuchs's anhydrides in dioxan with ammonia as catalyst; the main components were the anhydrides of γ-methyl glutamate and ε-N-carbobenzyloxylysine. (2) Removal of side-chain protective groups to give water-soluble polypeptides containing glutamic acid and lysine.

Polypeptides which would control grain-growth in the manner required resulted when highly purified intermediates and controlled amounts of initiator were used at the polymerization stage. Only in this way may compounds of high molecular weight be obtained, according to Blout *et al.*[2]. The observations of the latter in respect of the polymerization of γ-methyl-L-glutamate anhydride have been confirmed. When prepared by the method of Hanby *et al.*[3], γ-methyl glutamate itself was found to contain persistent traces of glutamic acid which could not be removed except by an anion-exchanger. The corresponding Leuchs's anhydride, after several recrystallizations, had m.p. 104° as against the reported values of 96–97°[3] and 99–100°[2]. Polymethyl glutamate prepared from this had η_i (in dichloracetic acid) = 1·32. Referred to data of Doty *et al.*[4] on the benzyl ester, this represents a molecular weight of about 200,000. Previous samples of the polypeptide from not specially purified anhydride had $\eta_i \sim 0{\cdot}1$. For the other main component, DL-lysine was used, as it was not found possible to purify L-lysine (natural origin) satisfactorily. The pure ε-N-carbobenzyloxylysine anhydride had m.p. 110°.

Co-polymers have been prepared from the above two anhydrides in various proportions, alone and admixed with proportions of another neutral amino-acid anhydride, namely, glycine, phenylalanine, cystine, proline or sarcosine. Elementary analyses of the products were in good agreement with expectation based on a long chain (so that end groups can be ignored). Discrepancies previously noted[5] may perhaps be ascribed to chain-branching and termination reactions, due to an excess of initiators in the intermediates.

Water-soluble polypeptides (stage *b*), co-polymers of glutamic acid and lysine alone or with the other amino-acids mentioned, were prepared by mild treatment of the above with hydrogen bromide in acetic acid, followed by precipitation with ether and dissolution in weak alkali. The last operation was facilitated by the presence of proline or sarcosine, presumably because of the reduced tendency to form intermolecular linkages on the peptide nitrogens which, with these two amino-acids, do not have a

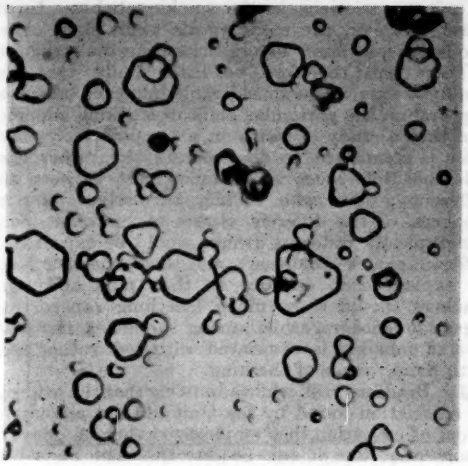

Fig. 1. Photomicrograph of silver iodobromide grains grown in the presence of a polypeptide of expected formula $Glu_4Lys_2Sar_2Cys_{6\cdot1}$. No other colloid was present at any time during the preparation of the emulsion or slide. (× 2,500)

hydrogen substituent. This observation was useful when dissolving polypeptides containing cystine, the disulphide group of which is very sensitive to alkali. The products were isolated from the neutralized aqueous solutions by precipitation with alcohol and, in this respect, resembled gelatin. They are in general freely soluble in water at all *p*H-levels. Although polyglutamic acid itself is insoluble in water, a minor amount (20 per cent) of lysine in the co-polymer is sufficient to prevent precipitation. Glutamic acid is less effective at the other end of the scale and co-polymers with relatively large proportions of lysine (> 80 per cent) are insoluble at high *p*H.

Flat, well-shaped silver halide grains have been grown in many of the polypeptides prepared, including those containing only glutamic acid and lysine. The composition is not critical, nor does it need to be complex. In support of this, it may be mentioned that grain-growth has also been produced using the soluble form of silk fibroin[6], a protein with a simpler amino-acid structure than gelatin. The important point is that the required grain growth was only achieved when pure intermediates had been used. From the above data on polymethylglutamate it is believed (though not proved) that the result is indicative of high molecular weights. An example of silver halide grains ripened in the presence of one of the water-soluble polypeptides is shown in Fig. 1.

None of the polypeptide solutions at any *p*H or concentration-level gave true gels. The nearest approach was with compounds containing large amounts of lysine, which gave gelatinous precipitates at high *p*H. Some observations have been made relative to the hypothesis of Grabar *et al.*[7] that gelation depends on the presence of arginine units in gelatin. The hypothesis rests on the fact that the power to gel is destroyed by hypobromite, a reagent known to disrupt guanidino groups. The matter has been further studied by Davis[8], and Janus[9] has found that guanidation of gelatin increases gel rigidity. The chemical effect of guanidating gelatin has been analysed by Eastoe *et al.*[10].

Polypeptides containing glutamic acid with ornithine or lysine have been treated with O-methylisourea at *p*H 10. This reagent converts ornithine to arginine and lysine to homoarginine. (Polyarginine has previously been prepared along these lines by Katchalski *et al.*[11].) The products were again isolated by alcohol precipitation of the neutralized solutions. The completeness of the guanidation could be checked conveniently by paper electrophoresis of hydrolysates. In phthalate buffer at *p*H 6, the mobilities towards the cathode of arginine and homoarginine are the same, as are those of ornithine and lysine; the ratio of the mobility of the first pair to that of the second is 0·85. Ornithine may thus be separated from arginine or lysine from homoarginine in a few hours. Glutamic acid moves away in the direction of the anode.

Guanidation of the polypeptides did not introduce the ability to gel. (The properties as regards control of grain-growth were also unaffected.) The result suggests that the arginine unit of gelatin does not play the decisive part in gelation, envisaged by Grabar *et al.* It seems likely that the reagent used by the latter will destroy or brominate important groups other than guanidino; for example, peptide. The effect of blocking the nitrogen of the peptide groups is seen in polypeptides containing sarcosine, which are not only easier to convert to the soluble form (cf. above) but give much less viscous aqueous solutions, implying reduced molecular interaction.

Just as this account had been completed, a communication appeared emphasizing the importance of peptide groups: in it, Bello *et al.*[12] show that gelation is inhibited by forming copper-peptide complexes.

Some success having been achieved in the aim of simulating the properties of gelatin, as regards control of grain-growth, with essentially simpler synthetic polypeptides, it is proposed to continue the search for the gelling factor(s). Clearly, something other than a polypeptide backbone is required in the molecule. In view of its unique occurrence in collagenous proteins, hydroxyproline (not yet incorporated in the present polypeptides) is of obvious interest. A more remote possibility is that the polysaccharide 'impurity' of gelatin[13] is important. If a particular sequence of amino-acid residues is involved, the present synthetic method is unlikely to be useful. It has long been known that side-chain polar groups do not play an important part in gelation, since the latter is not dependent upon *p*H[14]. The main function of these groups in the polypeptides is to confer solubility in water.

Thanks are due to Messrs. D. J. Farmery and J. P. Johnson for technical assistance and to the Directors of Ilford, Ltd., for permission to publish this communication.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Lung Cancer and Cigarettes?

The association observable between the practice of cigarette smoking and the incidence of cancer of the lung, to which attention has been actively, or even vehemently, directed by the Medical Research Council Statistical Unit, has been interpreted, by that Unit, almost as though it demonstrated a causal connexion between these variables.

The suggestion[1], among others that might be made on the present evidence, that without any direct causation being involved, both characteristics might be largely influenced by a common cause, in this case the individual genotype, was indeed rejected with some contempt by one writer[2], although I believe that no one doubts the importance of the genotype in predisposing to cancers of all types.

It seemed to me that although the importance of this factor had been overlooked by the Unit in question, it was well within the capacity of human genetics, in its current state, to examine whether the smoking classes to which human beings assign themselves, such as non-smokers, cigarette smokers, pipe smokers, cigar smokers, etc., were in fact genotypically differentiated, to a demonstrable extent, or whether, on the contrary, they appeared to be genotypically homogeneous, for only on the latter view could causation, either of the disease by the influence of the products of combustion or of the smoking habit by the subconscious irritation of the postulated pre-cancerous condition, be confidently inferred from the association observed.

The method of inquiry by which such differentiation can be recognized is the same as that by which the congenital factor has been demonstrated for several types of disease[3], namely, the comparison of the similarities between monozygotic (one-egg) and dizygotic (two-egg) twins respectively; for any recognizably greater resemblance of the former may be confidently ascribed to the identity of the genotypes in these cases.

I owe to the generous co-operation of Prof. F. von Verschuer and of the Institute of Human Genetics of the University of Münster the results of an inquiry into the smoking habits of adult male twin pairs on their lists.

The data so far assembled relate to 51 monozygotic and 31 dizygotic pairs, from Tübingen, Frankfurt and Berlin. Of the first, thirty-three pairs are wholly alike qualitatively, namely, nine pairs both non-smokers, twenty-two pairs both cigarette smokers and two pairs both cigar smokers. Six pairs, though closely alike, show some differences in the record, as in a pair of whom one smokes cigars only, whereas the other smokes cigars and sometimes a pipe. Twelve pairs, less than one-quarter of the whole, show distinct differences, such as a cigarette smoker and a non-smoker, or a cigar smoker and a cigarette smoker.

By contrast, of the dizygotic pairs only eleven can be classed as wholly alike, while sixteen out of thirty-one are distinctly different, this being 51 per cent against 24 per cent among the monozygotics.

The data can be rearranged in several ways according to the extent to which attention is given to minor variations in the smoking habit. In all cases, however, the monozygotic twins show closer similarity and fewer divergencies than the dizygotic.

There can therefore be little doubt that the genotype exercises a considerable influence on smoking, and on the particular habit of smoking adopted, and that a study of twins on a comparatively small scale is competent to demonstrate the rather considerable differences which must exist between the different groups who classify themselves as non-smokers, or the different classes of smokers. Such genotypically different groups would be expected to differ in cancer incidence; and their existence helps to explain such oddities as that pipe and cigar smokers should show much less lung cancer than cigarette smokers, while among the latter, the practice of inhaling is associated with less rather than with more cancer of the lung.

Dr. Bradford Hill, while admitting that the evidence of association found by his Unit did not amount to proof of causation, has emphasized that he does not know what else it can be due to. The facts here reported do show, however, that the choice is not so narrow as has been thought.

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Measurement of Toughness in Cold-stored Fish

Luijpen recently noticed[1] that the proportion of fish muscle protein that would dissolve in 5 per cent sodium chloride solution was not correlated with the development of toughness during cold-storage at or below −20° C. The discovery was of great significance to the study of cold-storage phenomena, because it implied that the soluble protein nitrogen (usually expressed as a percentage of the total protein nitrogen) could not now be used as an objective standard for the quality of cold-stored fish. This was contrary to former belief.

It seems likely, therefore, that future investigations of freezing and cold-storage of fish will require the direct estimation of toughness as a measure of quality change. A satisfactory method for measuring toughness does not, however, exist at present. Assessment by a taste panel is time-consuming and inaccurate, and can only deal with a few samples at a time. Machines such as penetrometers, various types of shear apparatus, etc., which successfully estimate the toughness of beef muscle, are not as a rule adaptable to fish because the fibres in the latter case are extremely short and interspersed with sheets of connective tissue (myocommata) which are tougher than the muscle itself.

The following method, which requires only a small piece of fish muscle, was therefore devised. It has so far been tried out only on uncooked cod (*Gadus callarias* L.).

A handle was made to hold two Swann–Morton No. 24 scalpel blades 3 mm. apart and parallel. By means of a gentle sawing action, the blades were sunk into a wide myotome (muscle segment) on the 'bone' side of the fillet, at right angles to the long

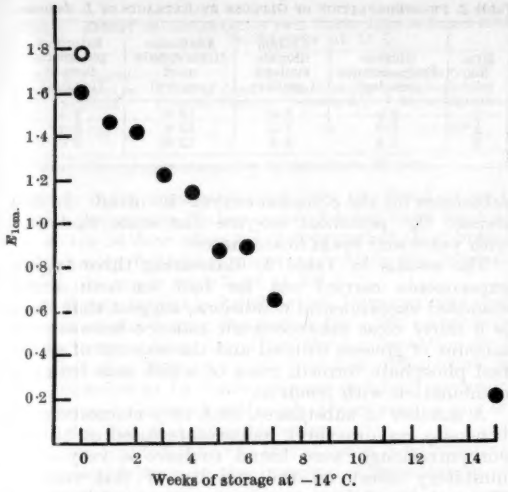

Fig. 1. Optical density of brei obtained by homogenizing muscle from cod fillets, frozen in 12 hr. and stored, wrapped, at −14° C. for different times. Each point is the average for thirty fillets determined in duplicate. ○, Fresh muscle before freezing; ●, frozen and thawed

axis, in the block of muscle lying immediately dorsal to the lateral line. The 'double scalpel' was then withdrawn with a slight twisting movement, so that a piece of muscle containing fibres of uniform length became detached from the fish and could be poked out from between the blades. It was freed from any traces of connective tissue, and two aliquots, each of 200 ± 5 mgm., were weighed out on a torsion balance.

20 ml. of approximately 1 per cent formaldehyde solution were used to fill the metal cup of a Marsh–Snow homogenizer[2] which had been fitted with a baffle plate just above the paddle blade to prevent frothing. The weighed sample was added to this, and the homogenizer run for 20 sec. at about 2,200 r.p.m. It was important not to put the tissue in before the formaldehyde. The resulting homogenate was poured with minimum delay into a ¼-cm. optical cell, and the optical density read immediately with a photometer. The wave-length of the incident light was selected so that the readings were conveniently placed on the scale of the photometer. In the present experiments a 430 mμ filter with a Hilger 'Biochem' absorptiometer was satisfactory. It was important to avoid any trace of frothing, and in this connexion the formaldehyde was kept below 20° C., being most satisfactory when cooled below 10° C. before the start of the experiment.

It was observed that the fibres from fresh fish muscle were completely broken up by this treatment, making an optically dense 'soup'. Frozen fish showed an increasing proportion of intact fibres in the brei as the storage time increased, until eventually only intact fibres were found, suspended in clear liquid which let through much more light. The optical density in the intermediate stages decreased regularly according to the number of intact fibres present.

Microscopic examination of breis from fish of intermediate toughness showed that, while a few fibres appeared to have been split longitudinally[3], the majority were either completely dispersed as fine fibrils or completely intact. This seems to show that 'toughness' is related to the cell envelope, destruction of which releases all the fibrils, which it would not do if the cells as a whole were becoming tougher.

Fig. 1 shows the changes in texture of frozen cod fillets, as measured by the new method, that occurred during cold storage at −14° C. It will be seen that freezing itself increased toughness and that the fish then became progressively tougher during subsequent storage. The immediate effect of freezing can usually be detected qualitatively by a taste panel, but as a rule it is not possible to measure subsequent changes in texture with any precision by this means.

We would thus seem to have a satisfactory method for assessing the texture of frozen fish. There are several possible factors such as the effects of the size of the fish and the treatment before freezing, manner of freezing, etc., which have not yet been examined. As these would be genuine changes in texture, however, they would not affect the validity of the results, but only their interpretation.

It is hoped to publish a full report of these investigations elsewhere.

I am indebted to Mr. Harry Bruce, who made the homogenizer and the special scalpel, and to Miss Eleanor Brown for technical assistance. The work described is part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research.

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Hexokinase Activity in Cell-free Extracts of *Leishmania donovani*

Leishmania donovani, the protozoan organism causing visceral leishmaniasis, is known to utilize glucose and other carbohydrate substrates for its continued metabolic activity. The evidence available, however, does not show whether phosphorylation plays a direct or an indirect part in the utilization of carbohydrates by this organism. During an investigation into the mechanism of utilization of various carbohydrates by *L. donovani*, strong hexokinase activity has been detected in the cell-free extracts of this organism. *L. donovani*, strain 81, cultured on Ray's medium[1] at 24° C. and recycled every three weeks from the N.N.N. medium, was used in this study. After growth for three days on Ray's medium, the organism was scraped from the surface of the agar, washed once with ice-cold isotonic saline and ground with glass powder, with gradual additions of ice-cold isotonic saline. Isotonic potassium chloride in place of sodium chloride was found to be equally satisfactory. The crushed suspension was centrifuged at 3,000 r.p.m. for 5 min. and the supernatant was used as crude enzyme extract.

Hexokinase activity has been followed by three different methods: (*a*) the manometric method of Colowick and Kalckar[2], (*b*) measurement of disappearance of free sugar by Nelson's method[3] and (*c*) the phosphorus-balance method, measuring the utilization of acid-labile phosphate and the concomitant formation of esterified phosphate.

Standard conditions for the assay of the hexokinase activity were as follows: 3·0 ml. of the complete reaction mixture contained 10 μmoles of substrate, 20 μmoles of the sodium salt of adenosine triphosphate, 10 μmoles of magnesium sulphate, 180 μmoles of sodium fluoride, 30 μmoles of sodium bicarbonate (*p*H 7·4), 1 cm.³ of enzyme extract containing 0·3–0·35 mgm. total nitrogen. Incubations were carried out in conventional Warburg manometric vessels at 37° C. in an atmosphere of 95 per cent nitrogen and 5 per cent carbon dioxide.

The rate at which carbon dioxide was evolved from the bicarbonate buffer, after due corrections for any adenosine triphosphatase and other non-specific activities destroying adenosine triphosphate, gave an approximate measure of the hexokinase activity. For measuring the amount of sugar utilized due to the hexokinase activity, aliquots of the samples at different time intervals were treated with barium hydroxide and zinc sulphate, using Somogyi's method[4], and the free reducing sugars were analysed by Nelson's method[3]. A control experiment was carried out without adenosine triphosphate and the activity was expressed on the basis of net difference in free glucose over the control. Acid-labile phosphate was determined by estimating the inorganic phosphate released after heating an aliquot with 1 *N* hydrochloric acid at 100° C. for 7 min. Esterified phosphate was estimated from the difference in the amount of adenosine triphosphate used up and the inorganic phosphorus liberated during incubation. Phosphorus estimations were done by Fiske and Subbarow's method[5]. All the sugars used in this study were of *dextro*-varieties.

Typical rates of output of carbon dioxide in the presence of different sugars are shown in Table 1. In the case of *d*-glucosamine, no correction was made, however, for its acid-binding power in the present experimental conditions. From the relative phosphorylation-rates given in Table 1, it will be noted that the hexokinase activity in the cell-free extracts of this protozoal organism is very marked towards glucose, fructose, mannose and *d*-glucosamine, whereas with galactose, glycerol and ribose the activity seems to be a little weaker. The presence of such an active glucosamine-phosphorylating enzyme suggests that this amino-sugar may play some important part in the metabolism of *L. donovani*. In order to characterize the substrate specificity of this hexokinase, some preliminary experiments were carried out, using mixtures of hexoses and *d*-glucosamine, on the rate of phosphorylation. The results indicate that for glucose, fructose, mannose, galactose and *d*-glucosamine a single hexokinase enzyme may be involved, since there is a mutual inhibitory effect on the rate of glucose phosphorylation in presence of either fructose, galactose, mannose or *d*-glucosamine. This inhibition may apparently be due to competition of all the substrates for the common enzyme involved. In this respect the protozoal enzyme has some similarity with yeast and brain hexokinases[6].

Table 1. Phosphorylation of Different Sugars by Cell-free Extracts of *L. donovani*

Substrate used (0·01 *M*)	Carbon dioxide liberated (μl.) at different time intervals (min.)					
	5	10	15	20	25	30
Glucose	20	38	53	63	70	75
Fructose	21	40	54	63	71	78
Mannose	16	30	43	51	58	64
Galactose	8	14	18	22	25	27
d-Glucosamine	16	32	47	59	69	74
Glycerol	5	3	1	—	—	—
Ribose	4	2	1	—	—	—

Table 2. Phosphorylation of Glucose by Extracts of *L. donovani*

Exp. No.	Glucose disappearance (μmoles)	Carbon dioxide evolved (μmoles)	Adenosine triphosphate used (μmoles)	Esterified phosphate formed (μmoles)
1	2·0	3·0	14·0	2·4
2	3·0	3·5	13·0	2·8
3	3·2	3·5	12·8	3·0

The results in Table 2, illustrating three typical experiments carried out for half an hour under standard experimental conditions, suggest that there is a fairly close stoichiometric balance between the amount of glucose utilized and the amount of esterified phosphate formed, most of which was found in combination with fructose.

A number of substances, such as *p*-chloromercuric benzoate, αα′-dipyridyl, iodoacetate (used at 10^{-4} *M* concentrations), were found to have a very small inhibitory effect on the activity of this enzyme. The activity of the enzyme extract was not improved by additions of cysteine or glutathione. These findings indicate that the hexokinase enzyme of *L. donovani* is not markedly dependent upon functional —SH groups for its activity.

Details regarding the substrate specificities, substrate affinities, *p*H optima and co-factor requirements of this enzyme will be published elsewhere.

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Effect of Larval Brain on the Imaginal Differentiation in the Silkworm

I have shown earlier[1,2] that, in *Bombyx mori*, pupal brain has a function which brings about imaginal differentiation, probably by affecting the prothoracic gland in the pupa, and that the mode of action by which the prothoracic gland is influenced is hormonal in nature. Kobayashi and Kirimura[3] attempted to extract the hormone and succeeded in obtaining an oily substance which is effective in bringing about imaginal differentiation in the 'Dauer-pupæ' from the extract of the pupal brain.

It has not yet been established, however, whether the larval brain has the same function in imaginal differentiation as the pupal brain. Accordingly, I have investigated this problem by implanting larval brain into the head of 'Dauer-pupa' of *Bombyx mori*.

The larvæ of the F_1 hybrid between two races, *J*115 and *C*108, were used as donors of brain and the 'Dauer-pupæ' of the hybrid between two races, *J*122 and *C*115, were used as recipients.

Brains to be tested were removed from the 5th instar larvæ on the fourth day after the fourth moult.

Table 1. Effect of Implantation of a Fresh Larval Brain into each 'Dauer-pupa' at 25° C.

No. of 'Dauer-pupae' used as recipient	No. of dead individuals	No. of moths emerged	Days from implantation to emergence
15 (♀)	1	14	18–25*

* Mean time from implantation to emergence, 20 days.

A fresh brain was implanted into the head of each 'Dauer-pupa', the 'Dauer-pupæ' having been kept at 25° C. for 30 days after being deprived of their brains immediately following pupation. After the implantation, the pupæ were kept at 25° C.

As shown in Table 1, 14 out of 15 pupæ operated became moths during the period from the eighteenth to the twenty-fifth day after the implantation and one died after five days. No imaginal differentiation was observed in 15 'Dauer-pupæ', in which no brain had been implanted although they were kept at 25° C. for 100 days after pupation.

It is concluded that the larval brain is as effective as the pupal brain in the imaginal differentiation of 'Dauer-pupa'.

In silkworm pupa, the brain hormone is elaborated in the neurosecretory cells of the brain and is released into the blood stream[2]. On the other hand, in the 4th and 5th larval stage the neurosecretory materials elaborated in the neurosecretory cells of the brain were released through two paths, one from the cell to the nervi corporis cardiaci through the axon of the *A*-cell, and the other from the cell to the blood stream through the cortex of the brain[2]. It is highly probable, therefore, that the secretory material released through the latter path is the brain hormone concerned with imaginal differentiation.

Thus it appears that even in the larval stage the secretion of the brain affects the prothoracic gland in *Bombyx mori*.

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A Correlation between the Compositions of Deoxyribonucleic and Ribonucleic Acids

We have shown that the composition of the ribonucleic acid of bacterial cells does not depend upon the very considerable changes in composition of deoxyribonucleic acid found when profound reorganizations of the hereditary nature of intestinal bacteria occur[1,2]. The composition of deoxyribonucleic acid in different bacterial species belonging to various systematic groups was shown to vary widely (from the extreme *AT*-type to the highest *GC*-type); whereas that of ribonucleic acid from these species was shown to vary slightly, small differences being noted only between very diverse species[3,4]. Thus the greater part of the ribonucleic acid of the cell appeared to be independent of the deoxyribonucleic acid.

However, a certain correlation was found to exist. This correlation is expressed in a tendency towards an increase in the ratio $\frac{G+C}{A+U}$ in ribonucleic acid when passing from the species with the smaller $\frac{G+C}{A+T}$ ratio in their deoxyribonucleic acid to those with greater values of this ratio[4].

We have studied the composition of the two nucleic acids applying methods[1] based on the mild alkali hydrolysis of the total bacterial mass (after removing acid-soluble substances) by means of a modified form of the method of Schmidt and Thannhauser. The composition of the ribonucleic acid was determined by paper chromatography of nucleotides; the composition of the deoxyribonucleic acid was determined by paper chromatography of bases. The eluates of spots were examined in the ultra-violet with a quartz spectrophotometer. Each result represents the mean of at least four single determinations in each of two parallel hydrolysates for each culture. The mean error of the mean values for nucleotides and bases presented in Tables 1 and 2 was not greater than 2 per cent. In both tables the species

Table 1. Composition of Bacterial Deoxyribonucleic Acids

Species	Bases (moles per cent)				$\frac{Pu}{Py}$	$\frac{G+T}{A+C}$	$\frac{G+C}{A+T}$
	G	*A*	*C*	*T*			
Clostridium perfringens	15·8	34·1	15·1	35·0	1·00	1·03	0·45
Staphylococcus pyogenes aureus	17·3	32·3	17·4	33·0	0·98	1·01	0·53
Pasteurella tularensis	17·6	32·4	17·1	32·9	1·00	1·02	0·53
Proteus vulgaris	19·8	30·1	20·7	29·4	1·00	0·97	0·68
Escherichia coli	26·0	23·9	26·2	23·9	1·00	1·00	1·09
Proteus morganii	26·3	23·7	26·7	23·3	1·00	0·98	1·13
Shigella dysenteriae	26·7	23·5	26·7	23·1	1·01	0·99	1·15
Salmonella typhosa	26·7	23·5	26·4	23·4	1·01	1·00	1·13
Salmonella typhimurium	27·1	22·9	27·0	23·0	1·00	1·00	1·18
Erwinia carotovora	27·1	23·3	26·9	22·7	1·02	0·99	1·17
Corynebacterium diphtheriae	27·2	22·5	27·3	23·0	0·99	1·01	1·20
Aerobacter aerogenes	28·8	21·3	28·0	21·9	1·00	1·03	1·31
Mycobacterium vadosum Kras.	29·2	20·7	28·5	21·6	1·00	1·03	1·37
Brucella abortus	29·0	21·0	28·9	21·1	1·00	1·00	1·37
Alcaligenes faecalis	33·9	16·5	32·8	16·8	0·98	1·03	2·00
Pseudomonas aeruginosa	33·0	16·8	34·0	16·2	0·99	0·97	2·03
Mycobacterium tuberculosis BCG	34·2	16·5	33·3	16·0	1·03	1·01	2·08
Sarcina lutea	36·4	13·6	35·6	14·4	1·00	1·03	2·57
Streptomyces griseus	36·1	13·4	37·1	13·4	0·98	0·98	2·73

Abbreviations: *G*, guanine; *A*, adenine; *C*, cytosine; *T*, thymine; *Pu*, purine bases; *Py*, pyrimidine bases.

Table 2. Composition of Bacterial Ribonucleic Acids

Species	Bases (moles per cent)				$\frac{Pu}{Py}$	$\frac{G+U}{A+C}$	$\frac{G+C}{A+U}$
	G	*A*	*C*	*U*			
Clostridium perfringens	29·5	28·1	22·0	20·4	1·36	1·00	1·06
Staphylococcus pyogenes aureus	28·7	26·9	22·4	22·0	1·25	1·03	1·05
Pasteurella tularensis	29·8	27·3	21·0	21·9	1·33	1·07	1·03
Proteus vulgaris	31·0	26·3	24·0	18·7	1·34	0·99	1·22
Escherichia coli	30·7	26·0	24·1	19·2	1·31	1·00	1·21
Proteus morganii	31·1	26·0	23·7	19·2	1·31	1·01	1·21
Shigella dysenteriae	30·4	25·9	24·4	19·3	1·29	0·99	1·21
Salmonella typhosa	30·8	26·1	24·0	19·1	1·32	1·00	1·21
Salmonella typhimurium	31·0	26·1	23·8	19·1	1·33	1·00	1·21
Erwinia carotovora	29·5	26·5	23·7	20·3	1·27	0·99	1·14
Corynebacterium diphtheriae	31·6	23·1	23·8	21·5	1·21	1·13	1·24
Aerobacter aerogenes	30·3	26·0	24·1	19·6	1·29	1·00	1·19
Mycobacterium vadosum Kras.	31·7	23·8	23·5	21·0	1·25	1·12	1·23
Brucella abortus	30·2	25·4	24·9	19·5	1·26	0·99	1·23
Alcaligenes faecalis	30·9	25·7	24·1	19·3	1·31	1·01	1·22
Pseudomonas aeruginosa	31·6	25·1	23·8	19·5	1·31	1·05	1·24
Mycobacterium tuberculosis BCG	33·0	22·6	26·1	18·3	1·25	1·05	1·45
Sarcina lutea	32·7	23·2	24·2	19·9	1·27	1·11	1·32
Streptomyces griseus	31·1	23·8	25·2	19·9	1·22	1·04	1·29

Abbreviations: *G*, guanylic acid; *A*, adenylic acid; *C*, cytidylic acid; *U*, uridylic acid; *Pu*, purine nucleotides; *Py*, pyrimidine nucleotides.

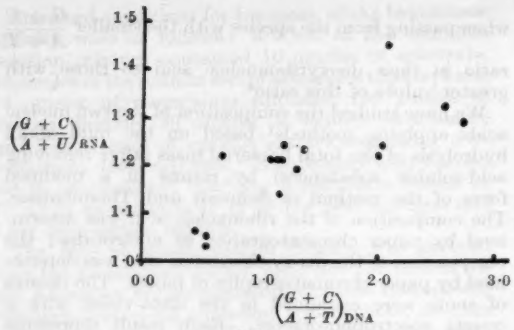

Fig. 1

are arranged in order of increase of the ratio $\frac{G+C}{A+T}$ in their deoxyribonucleic acid. The details have been published elsewhere[4].

The correlation is shown in Fig. 1, where the values of $\left(\frac{G+C}{A+T}\right)_{DNA}$ are plotted against those of $\left(\frac{G+C}{A+U}\right)_{RNA}$, each point corresponding to a species having characteristic values of the two ratios. There appears to be a positive correlation between the ratios $\left(\frac{G+C}{A+U}\right)_{RNA}$ and $\left(\frac{G+C}{A+T}\right)_{DNA}$ for the nineteen bacterial species studied; the correlation coefficient is 0·72, with a mean error of 0·17; that is, $r = +0{\cdot}72 \pm 0{\cdot}17$. The correlation coefficient is thus 4·3 times as large as its mean error.

The fact that the value of regression of $\left(\frac{G+C}{A+U}\right)_{RNA}$ on $\left(\frac{G+C}{A+T}\right)_{DNA}$ is very small explains why one encounters difficulties in studying the differences in composition of the ribonucleic acid of species differing drastically in the composition of their deoxyribonucleic acid.

It should be noted that the positive correlation between the compositions of the two nucleic acids has been established for only nineteen species of bacteria: further investigations are therefore necessary to show that this correlation is not fortuitous.

Nevertheless, our results suggest that part at least of the ribonucleic acid of the cell depends on the deoxyribonucleic acid, and that the two nucleic acids may even be similar with respect to their base compositions. On the other hand, the small value of the regression indicates that the greater part of the cell ribonucleic acid is relatively independent of the deoxyribonucleic acid.

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A Possible Mechanism for the Initial Transfer of the Genetic Code from Deoxyribonucleic Acid to Ribonucleic Acid

It is now a generally accepted hypothesis that deoxyribonucleic acid contains the genetic information in the living cell which ultimately directs the formation of protein. Moreover, there is some evidence that deoxyribonucleic acid acts as a template for the formation of ribonucleic acid which relays information to the protein polypeptide chain by another template mechanism. If this were so there should be a simple relation between the composition of ribonucleic and deoxyribonucleic acids, since there are only four commonly occurring base groups in each nucleic acid. The fact that this is not so is probably due to two factors: only a fraction of the nucleic acid in the cell functions as a template and, therefore, only this fraction would be pertinent when comparing base ratios of the two nucleic acids; there are several different templates (more than two) involved in the transfer of information from deoxyribonucleic acid to the polypeptide chain, and, as a result the general problem of information transfer might be more easily solved by consideration of each template and its immediate chemical product.

As an example of this approach, consider the relation between the two nucleic acids and concentrate on the ribonucleic acid that is most likely to be produced directly on the deoxyribonucleic acid. I shall assume that this is nuclear ribonucleic acid because of its close cytological connexion with deoxyribonucleic acid. Furthermore, a good deal of evidence has accumulated that the cell nucleus plays a crucial part in the metabolism of ribonucleic acid[1].

This limitation makes it difficult to test any coding mechanism because of the paucity of pertinent data, for example, the base composition of deoxyribonucleic acid and nuclear ribonucleic acid. Nevertheless, I wish to propose the following code because it suggests further experiments. The data presented in Table 1 are taken from the results of Chargaff[2] and Vincent[3].

Since deoxyribonucleic acid and ribonucleic acid are each associated with four types of base groups, one might expect to find an immediate one-to-one correspondence between their respective bases. Chargaff's data do not verify this expectation however, and such a scheme is immediately discounted. The problem of finding four specific sites on deoxyribonucleic acid for binding ribonucleic acid has a possible solution resulting from the helical character of the duplex of the former which, in effect, gives rise to different binding sites being associated with a given nucleotide base-pair depending upon which polynucleotide chain the individual nucleotide members are situated. Thus adenine on chain I paired with thymine on chain II would make a different site from adenine on chain II and thymine on chain I. These two sites are designated as $A - T$ I and $A - T$ II. Likewise the other two sites are designated $G - C$ I and $G - C$ II. In this code each deoxyribonucleic acid base-pair functions as a location for one ribonucleic acid base-group in a single chain, the sequence of base-groups in the latter being determined by the sequence of base-pairs in the former acid. The particular correspondence I would like to suggest is shown in Table 2.

(1) This code predicts a necessary relation between the base composition of the two nucleic acids such

Table 1

Source of ribonucleic acid	Nuclear ribonucleic acid					Deoxyribonucleic acid	Cytoplasm ribonucleic acid
	A/U	*G/C*	*Pu/Py*	*G + U/A + C*	*G + C/A + U*	*A + T/G + C*	*G + C/A + U*
Rat liver	0·85	0·88	0·86	1·00	1·26	1·33	1·59
Ox liver	0·81	0·87	0·83	1·01	1·28	1·25	1·59
Ox kidney	0·99	0·88	0·83	0·94	1·26	1·30	1·52
Starfish oocyte	1·47	1·34	1·38	1·04	1·74	1·78	1·42

Abbreviations: *A*, adenine; *G*, guanine; *C*, cytosine; *U*, uracil; *T*, thymine; *Pu*, purines; *Py*, pyrimidines.

that the ratio $\frac{A+T}{G+C}$ of the deoxyribonucleic acid should be equal to the ratio $\frac{G+C}{A+U}$ of the ribonucleic acid. Reference to columns 6 and 7 in Table 1 giving the nucleotide compositions indicates that this relation holds. Two other relations for base ratios produced by this code depend on the relative composition of the individual deoxyribonucleic acid chains: (2) The 6-amino/6-keto ratio of ribonucleic acid depends upon the relative purine/pyrimidine ratio of the two deoxyribonucleic acid chains and is equal to one when both these chains contain the same relative amounts. (3) The purine/pyrimidine ratio of the ribonucleic acid depends upon the relative 6-amino and 6-keto content of the two deoxyribonucleic acid chains and

Table 2

DNA base pair	RNA base determined
A–T I	guanine
A–T II	cytosine
G–C I	uracil
G–C II	adenine

is equal to 1 when these two chains contain the same relative amounts. From Table 1 we see that the relevant ribonucleic acid base ratios are not far from 1, although the 6-keto/6-amino ratio seems much closer to 1. It should be noted that I have not specified to which deoxyribonucleic acid chains I and II refer, and also that the code could be altered by interchanging the assignments for $A - T$ I and $A - T$ II (a template model has been built which would suggest that if the general code described here is correct, the assignments for $A - T$ I and $A - T$ II in Table 2 should be interchanged). This would have the effect of interchanging relations 2 and 3. In view of the fact that we have no data on the relative composition of the two chains we have no reason for preferring one system to the other. Moreover, there are so few data relevant to the proposal made here that we cannot be confident that the correlation found is general.

Work is in progress in this Research Unit to test the proposed code.

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Catechol Amine Depletion in the Rat's Denervated Adrenal Gland following Chronic Administration of Reserpine

RECENT observations have indicated that reserpine can depress not only 5-hydroxytryptamine, but also noradrenaline- and adrenaline-levels in brain, heart, spleen and other sympathetically innervated tissues[1–3]. The depletion of adrenal medullary hormones by single doses of reserpine has been attributed to a stimulation of centres in the central nervous system, since spinal transection at T_1 is reported to prevent this response[1].

In the present study the effects of chronically administered reserpine ('Serpasil') on the catechol amine content of the denervated and innervated adrenal glands of the rat have been investigated. Male litter mates, weighing approximately 250–300 gm. were used throughout. The left adrenal gland was denervated aseptically, approximately 7–10 days prior to the administration of reserpine. The reserpine was given intraperitoneally in a dose of 0·1 mgm./100 gm. for a period of 5 days. The control group of animals received a placebo which consisted of the reserpine diluent. The catechol amine content of the glands was extracted at 4° C. in a glass homogenizer using 5 per cent trichloracetic acid. The acid was removed by washing the extract with 3 volumes of peroxide-free diethyl ether[4]. Bio-assay was performed using the cat's blood pressure in a preparation which had been pretreated with hexamethonium, atropine and diphenhydramine[5]. Total catechol concentrations were obtained in noradrenaline equivalents. All results were subjected to set or paired comparisons using the *t*-ratio for the determination of statistical significance.

A marked depression in catechol amine-levels was obtained in both the denervated and innervated glands after the administration of reserpine for 5 days (Table 1). A comparison with placebo-treated controls indicated that this depletion was of a high order of significance (Table 2; 1, 2). The innervated and denervated glands in each of the two experimental groups when subjected to a paired comparison revealed no significant differences (Table 2; 3, 4). This suggests that reserpine may deplete the denervated gland to about the same degree as the innervated one.

These results demonstrate that the depleting action of reserpine on medullary amines may occur in the

Table 1. ADRENAL MEDULLARY CATECHOL AMINE-LEVELS (μGM./KGM. BODY-WEIGHT)

	Placebo		Reserpine	
	Mean ± S.E.M.	No. of animals	Mean ± S.E.M.	No. of animals
Innervated gland	22·2 ± 2·8	12	11·5 ± 2·0	14
Denervated gland	21·5 ± 1·4	12	10·5 ± 1·7	14

Table 2. Statistical Analysis

	Comparison	Method of analysis	*P* value
1	'Serpasil' (*D*)—Placebo (*D*)	Group comparison	< 0.01
2	'Serpasil' (*I*)—Placebo (*I*)	Group comparison	< 0.01
3	'Serpasil' (*D*)—'Serpasil' (*I*)	Paired comparison	> 0.2
4	Placebo (*D*)—Placebo (*I*)	Paired comparison	> 0.5

D, Denervated gland; *I*, innervated gland.

absence of any direct neural connexion with the central nervous system.

Since chronic reserpine administration causes the release of both noradrenaline and adrenaline from the rat's adrenal gland and does not apparently impede the normal rate of re-synthesis of these substances (ref. 6 and B. L. Mirkin, unpublished results), it is probable that the peripheral effect which has been observed is due to some action on those mechanisms which regulate the storage and release of catecholamines from the adrenal medulla.

This aspect of the problem is at present under investigation.

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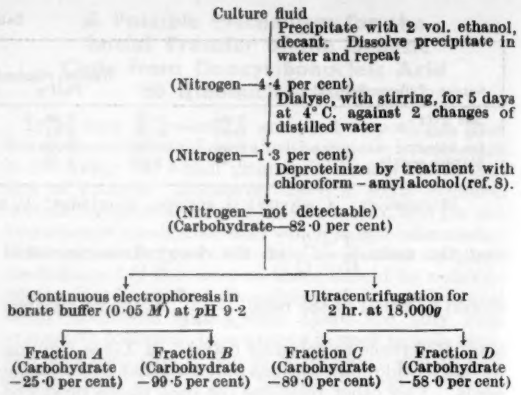
Extracellular Metabolic Products of a *Hirsutella* Species

A species of *Hirsutella*, parasitic on larvæ of the spruce budworm (*Choristoneura fumiferana* (Clem.))[1], when grown in liquid culture produces a highly viscous metabolite. Preliminary tests indicated that this substance might be a polysaccharide and since it has been reported that polysaccharides produced by some parasitic fungi can cause significant reactions in the host[2], it seemed desirable to investigate this material.

The fungus was grown in a liquid medium containing 1 per cent glucose and 1 per cent 'Difco' yeast extract. 100-ml. portions of the sterile medium in 250-ml. flasks were inoculated, incubated for 7–10 days at 25° C. on a rotary shaker, pooled, centrifuged, and the supernatant fluid collected.

The addition of two volumes of ethanol or acetone to one volume of the culture fluid precipitates the viscous material. Spot tests on this precipitate gave positive results for the presence of carbohydrates and proteins and/or amino-acids. Reducing sugars were detected only after acid hydrolysis of the sample. Negative results were obtained in tests for pentoses, galactose and glucuronates, while ether extraction of


Culture fluid
Precipitate with 2 vol. ethanol, decant. Dissolve precipitate in water and repeat
(Nitrogen—4·4 per cent)
Dialyse, with stirring, for 5 days at 4° C. against 2 changes of distilled water
(Nitrogen—1·3 per cent)
Deproteinize by treatment with chloroform – amyl alcohol (ref. 8).
(Nitrogen—not detectable)
(Carbohydrate—82·0 per cent)
Continuous electrophoresis in borate buffer (0·05 M) at pH 9·2
Ultracentrifugation for 2 hr. at 18,000g
Fraction A (Carbohydrate —25·0 per cent)
Fraction B (Carbohydrate —99·5 per cent)
Fraction C (Carbohydrate —89·0 per cent)
Fraction D (Carbohydrate —58·0 per cent)

an acid hydrolysate of the sample gave no evidence for the presence of lipids.

The material was purified as in the scheme above. During the fractionation in the continuous electrophoresis apparatus fraction *A* was collected directly below the point of application. Fraction *B* migrated toward the anode but was carried down the paper at such a slow rate that it had not reached the bottom edge before the end of the run. However, as the streak was clearly visible it was cut from the paper, eluted with water, filtered through a sintered glass funnel to remove cellulose fibres, and freed of borate[3].

When the deproteinized culture fluid was centrifuged for 2 hr. at 180,000*g*, it yielded a semi-solid sediment and a non-viscous supernatant which could be siphoned off. The sediment (after washing 4–6 times with water) and the supernatant were freeze-dried and designated fractions *C* and *D* respectively.

The time-reaction curves of all four fractions with anthrone were, in general, similar to those reported by Koehler[4] for the polyhexoses glycogen, dextrin and amylose. The shape of these curves indicated that the samples contained aldohexoses only.

Hydrolysis of the samples by refluxing with 1 *N* sulphuric acid resulted in the formation of considerable amounts of humin and almost complete destruction of the sugars. However, by heating with 2 *N* formic acid in sealed tubes at 120° C. complete hydrolysis could be obtained with destruction of less than 5 per cent of the carbohydrates. Chromatograms of the hydrolysates of fractions *A* and *B* showed three spots, two of which were identified as glucose and mannose but the third was not identified. When hydrolysates of fractions *C* and *D* were subjected to chromatography only two spots, corresponding to glucose and mannose, were apparent. It appeared, therefore, that the third component in fractions *A* and *B* might be an artefact formed during the fractionation by electrophoresis, possibly due to the long exposure to alkali.

The sugars were also identified by filter paper electrophoresis of the hydrolysates[5]. Glucose was further confirmed by treating the hydrolysates with glucose oxidase. Chromatography of the treated samples showed that one spot, corresponding to the glucose standard, had disappeared.

The infra-red spectra of the fractions gave some additional information on the nature of these carbohydrates. A peak at $890 \pm 10{\cdot}5$ cm.$^{-1}$ in all the samples can be attributed to a β-linkage in the polysaccharides. There was no evidence of a peak at

844 cm.$^{-1}$ in any fraction, which indicates that the α-linkage is not present to any extent in these samples[6]. All four fractions gave a peak (814 ± 9·5 cm.$^{-1}$) which appeared to be similar to a type 3 peak of mannan. Other peaks given by fractions *A* (917 cm.$^{-1}$) and *B* (947 ± 1·4 cm.$^{-1}$; 774 ± 1·2 cm.$^{-1}$) are typical of hexoses in general and could not be attributed to any particular sugar[7].

Sedimentation curves gave an indication of the homogeneity of the samples. The deproteinized, but unfractionated sample was heterogeneous but contained two principal components. Fraction *A* was heterogeneous with no predominant component but fraction *B* gave a single, sharp peak indicating that it was relatively homogeneous. Both fractions *C* and *D* were heterogeneous, but each contained one main component.

This fungus produces a number of extracellular polysaccharides, though there appear to be two main constituents in the mixture. While these polysaccharides are similar in some respects, for example, constituent sugars and β-linkages, there are differences in molecular weights and in viscosities. The one polysaccharide isolated in a relatively pure form differs from the others in that it can form a charged complex with borate. Since the formation of borate complexes depends on the location of free hydroxyl groups in the polymer, a difference in the position of the glycosidic linkage in the polymers may be indicated.

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Purine Excretion by the Sheep Ked, *Melophagus ovinus* (L.)

The major nitrogenous excretory product of adult insects is uric acid[1]. Small amounts of the enzymes adenase and guanase have been reported in *Hydrophilus* and *Dytiscus*[2] and in *Prodenia* and *Tenebrio*[3]. Larvæ and pupæ of *Antheraea pernyi* Guér. (Lepidoptera) contain adenine, hypoxanthine and xanthine[4]. At Lethbridge, female sheep keds have been found to excrete xanthine and hypoxanthine as well as uric acid. Male keds excreted only uric acid.

Purines were determined chromatographically by adapting the method of Vischer and Chargaff[5]. Direct squashes of the hæmolymph, Malpighian tubules, and iliac bulb contents of two or three insects were made on Whatman No. 4 filter paper, each squash being treated with 0·5 *N* sulphuric acid after spotting. About 0·05 ml. of a standard mixture (hypoxanthine, 0·1 per cent; xanthine and uric acid, saturated solutions) in 0·5 *N* sulphuric acid was spotted on the paper and run beside the squashes. Chromatograms were run by the descending technique for 16 hr. in a system composed of *n*-butanol/diethylene glycol/water (4 : 1 : 1), in an atmosphere saturated with this material and with ammonia. The latter neutralized the sulphuric acid used in spotting the standards and samples. Chromatograms were air-dried, oven-dried for 30 min. at 40° C., sprayed with a 0·5 *M* solution of mercuric nitrate in 0·5 *N* nitric acid, washed in 0·5 *N* nitric acid and running tap-water, and developed in ammonium sulphide solution. Purines appeared as black spots of mercuric sulphide.

Great variation was noted in the amounts of xanthine and hypoxanthine from random samples of female keds, and an attempt was made to discover the source. Chromatograms of hæmolymph, tubules, and iliac bulb contents of females containing no larva in the vagina showed only uric acid, whereas those containing a small larva exhibited traces of xanthine as well. Squashes from females containing a large larva produced xanthine spots as dense as or denser than the uric acid spots, as well as small spots of hypoxanthine, which was usually demonstrable only in the iliac bulb contents. It was concluded that the xanthine and hypoxanthine were produced in larval metabolism.

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Formation of Antifungal Antibiotics by a New *Streptomyces* Species

Two closely similar strains of a new species of *Streptomyces* (Nos. 1033 and 1038) were isolated from the Champavathi river mud (Andhra Pradesh) and Bangalore virgin soil (Mysore State). Their morphological and biochemical characteristics (Table 1) appear similar to those of *Streptomyces viridans* (Waksman and Henrici's classification)[1], but they are readily differentiated from the latter by the formation of straight sporophores and aerial mycelium in circles and tufts, and the elaboration of antifungal substances.

A mixture of three antibiotics, *A*, *B* and *C*, extractable with *n*-butanol from broths and mycelia, is formed after growth for 48–72 hr. in shake-cultures containing molasses and peptone at 28° C. None of them has yet been obtained in the crystalline state. These are characterized by a high degree of inhibitory activity (0·2–0·5 μgm./ml.) *in vitro* against *Saccharomyces cereviseae*, *Candida albicans*, *C. tropicalis*, *Zygosaccharomyces priorianus*, *Torulopsis pulcherimma*, *T. utilis*, *Rhodotorula glutinis*, *Geotricum* sp. and a few other fungi tested. They are inactive towards *Micrococcus pyogenes* var. *aureus*, *Escherichia coli* and *Bacillus subtilis*. The mixture of the antibiotics separates into three spots (R_F values, 0·0; 0·33 and 0·95, respectively) on one-dimensional ascending paper chromatograms (Whatman No. 1 paper) developed with benzene/acetic acid/water (2 : 2 : 1 —organic layer) at 26° C. While *A* and *B* give

Table 1. Characteristics of the Organisms after Incubation for Seven Days at 28° C.

Media (ref. 2)	Description of colony	Reverse side	Aerial mycelium	Soluble pigment
Yeast-glucose agar	Good growth, round, raised; older colonies often cleave	Moss green	Light grey with greenish tinge, concentric, abundant velvety rings and tufts. Sporophores curved; spores globose	Greenish, darkening later
Nutrient salt agar	,,	,,	,,	,,
Glucose–peptone agar	,,	,,	,,	Slight
Meat peptone agar	As above, but flattened; growth, poor	Yellowish green	,,	None or faint
Emerson's agar	As on yeast–glucose	Moss green	,,	Yellowish green
Bennet's agar	,,	,,	,,	,,
Potato-glucose agar	,,	Deep reddish brown	,,	Negligible
Starch agar	Small and flattened (starch hydrolysed)	Moss green (formation slow)	,,	Faint
Czapek's agar	,,	Yellowish green	As above, but less abundant	Nil
Calcium malate agar	Small, round, raised, yellow vegetative mycelium. Digestion of the salt	Yellow with brownish centre	As above (excepting the peripheral region)	Nil
Egg-albumin agar	Thin, spreading; growth: slow, poor and colourless	White or pale yellow	As above, but poor and slow	Nil
Glucose–asparagine agar	With elevated centre; slow growth	Yellowish green	,,	Nil
Gelatin liquefaction	Complete in 6–7 days			
Nitrate reduction	After 6–7 days			
Milk	Peptonizes completely after 10 days; alkaline			

Carbon compounds utilized for growth: arabinose, glucose, galactose, sucrose, maltose, starch.
Carbon compounds not utilized for growth: raffinose, rhamnose, lactose, dulcitol, sorbitol.

absorption curves ($\lambda_{max.}$ 360, 380, 405 mμ) characteristic of the heptaene group[3], no selective absorption is noticeable in the case of *C* in the region of 250–400 mμ. Their chromatographic behaviour on paper strips (developed with various solvent systems[4]), solubility and spectral characteristics, and antimicrobial activity together indicate that, in any event, *B* and *C* are entirely different from any known and well-characterized antifungal substances formed by *Streptomyces* species.

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Toxicity of Urea to Sheep

It is generally accepted that urea is toxic when fed at levels greater than 30–35 gm. per sheep a day. Clark *et al.*[1] produced toxic effects by drenching sheep with 10 gm. of urea. Peirce *et al.*[2] killed many sheep when they fed 25–45 gm. of urea per sheep a day; in this experiment, the daily ration of urea was consumed over a period of approximately 1 hr. By adjusting the method of feeding, we have found it possible to feed sheep up to 100 gm. of urea a day with no mortality.

Although the mechanism of urea toxicity is not fully understood, it is thought to be related to the production of ammonia by the rapid hydrolysis of urea in the rumen. This rise of rumen ammonia produces a rise of peripheral blood ammonia, and toxicity occurs when blood ammonia concentration rises above 8–12 μgm. ammonia–nitrogen/ml. However the ammonia concentration in peripheral blood does not rise until the rumen ammonia-level is raised above about 80 mgm. ammonia–nitrogen/100 ml.

It follows, therefore, that if the urea can be fed in such a way that rumen ammonia-levels never rise above 80 mgm. ammonia–nitrogen/100 ml., then no toxicity will result. This can be done by spraying the urea in solution over the sheep's ration of hay, or over the pasture which it is grazing. In this way, the daily ration of urea will be consumed in small quantities at intervals over the whole 24-hr period. Since ammonia is rapidly absorbed from the rumen, there will be no great build up of rumen ammonia.

A Corriedale wether weighing 58·5 kgm., and fitted with a permanent rumen fistula, was kept in a metabolism cage and fed a daily basal ration of 1,400 gm. chopped meadow hay (crude protein 7·0 per cent). From day to day, this was supplemented with varying amounts of urea and molasses, these being incorporated into the ration as a solution in water mixed thoroughly with the hay. The urea : molasses ratio by weight was kept at 1 : 4. Rumen samples were taken immediately before feeding and then at regular intervals after feeding for periods up to 24 hr. Rumen *p*H and rumen ammonia concentration were measured on each sample.

Fig. 1 shows rumen ammonia concentrations over a 14-hr. period after feeding 100 gm. of urea, and, for comparison, the effect of introducing 25 gm. of urea directly into the rumen, and of feeding hay alone. When 100 gm. of urea were fed with the hay, rumen ammonia-levels rose sharply and remained at high levels throughout the day, the levels fluctuating slightly according to times of eating. However, at no time did these levels rise above 80 mgm. ammonia–nitrogen/100 ml. Similar results have been obtained

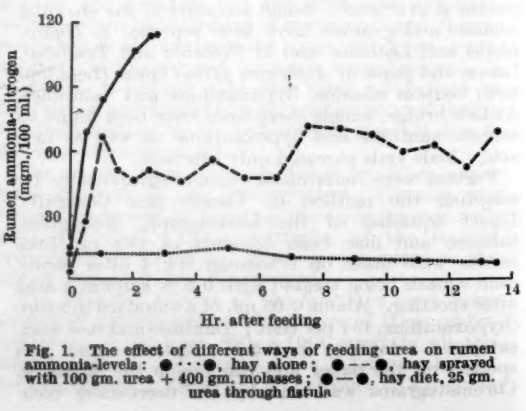

Fig. 1. The effect of different ways of feeding urea on rumen ammonia-levels: ●···●, hay alone; ●--●, hay sprayed with 100 gm. urea + 400 gm. molasses; ●—●, hay diet, 25 gm. urea through fistula

with other sheep both in metabolism cages and under field conditions.

Clearly, where urea is to be used as a supplement for grazing animals, it is desirable to feed it as a spray rather than as part of a concentrated ration, because toxicity is then no longer a problem. However, whether it is beneficial and economic to feed very high urea levels is doubtful.

It is interesting to note that when high levels of urea are fed, rumen *p*H rises to nearly 8, and both rumination and rumen movement are inhibited. Whether this rumen paralysis is caused by the ammonia *per se*, or is a consequence of rumen alkalosis, or is an osmotic effect, is not yet clear.

This work is continuing, and will be published in full elsewhere.

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Heparin Content of Adipose Tissue

There is now a well-established association between heparin and clearing factor[1,2] and between heparin and the mast cell[3]. It has long been known by histologists that mast cells "are numerous in parts where fat is being laid down"[4]. This, and the extraction of active clearing factor preparations from adipose tissue[5], suggested to us that heparin might be an essential agent in fat mobilization and deposition, and in consequence be present in all animal fat. As a preliminary step we have determined the amount of heparin in the adipose tissue of cattle and the study forms the subject of this communication.

The tissues, already carefully trimmed, were kindly supplied by Mr. A. J. Ross of the Glasgow Abattoir and his description of them appears in Table 1.

Table 1. The Heparin Content of Bovine Adipose Tissue before and after Defatting

Type of fat	I.U./gm. whole adipose tissue	I.U./gm. of defatted adipose tissue residue
Intestine	0·92	21·6
Rectum and anus	1·5	60·0
Liver	1·3	45·3
Cardiac	1·0	40·3
Uterus	2·0	56·9
Lung	3·89	130·5
Kidney	0·44	28·7
Tongue	0·88	28·3
Mesentery	1·5	45·01
Stomach	0·9	59·0

Each sample of approximately two kilos was defatted with hot alcohol and the fibrous residue dried *in vacuo*. The heparin was then extracted as follows.

The defatted tissue was homogenized in 10 per cent aqueous ammonium carbonate, heated to 70° C. and filtered. The residue was twice re-extracted using further ammonium carbonate solution and the extracts were combined. The crude heparin was precipitated with two volumes of alcohol, collected by centrifuging and dried. The precipitate was taken up in ammoniacal water to give a gelatinous solution which was treated with trypsin and then assayed for heparin.

We are indebted to our colleague Mr. J. Pritchard for the anticoagulant assays[6], and on a random selection of samples he also demonstrated that the anticlotting activity was inhibited by protamine, indicating that the activity was due to heparin or similar substances.

Table 1 summarizes the results and shows that all samples contain heparin in appreciable amounts.

We are indebted to the Directors of Evans Medical Supplies for providing the facilities to carry out this work.

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Difference between Lipoprotein Lipase and Post-Heparin Esterase in Human Serum

The basic component of the clearing factor[1] is a lipolytic enzyme which differs from hitherto known lipases[2]. Its lipolytic action can be demonstrated by the hydrolysis of the fatty components of lipoproteins[3]. When using β-naphthyl laurate[4], acetylcholine and butyrylcholine[5] as substrate the results are negative. With tributyrin the findings are conflicting[6]. If ethyl butyrate is used as substrate, raised esterolytic activity of the sera can be observed in man after the intravenous injection of heparin[7].

We consider that the acceleration of hydrolysis of ethyl butyrate is the result of the action of an enzyme other than the lipase of the clearing factor, which is definitely inhibited by protamine and heparin *in vitro*[8]. As against this, the post-heparin esterase splitting of ethyl butyrate is not inhibited by these substances (Table 1).

Table 1. The Resistance of Post-Heparin Esterase to Inhibition by Protamine and Heparin *in vitro*

Inhibitor of lipoprotein lipase	Amounts of inhibitor added per ml. serum	Esterase activity per ml. (μmol. of acid liberated from ethyl butyrate in 24 hr.) Pre-heparin serum	Post-heparin serum
Protamine	1,000γ	130	167
	100γ	131	166
	Control	130	167
Heparin	1,000 units	133	195
	100 units	135	198
	Control	135	195

In vitro, protamine inhibits post-heparin esterase only when it is added in excess[9]. Ordinary amounts, which inhibit the lipase of the clearing factor, have no effect, however, on post-heparin esterase. In accord with the findings of Levy and Swank[10], we found that protamine has an inhibitory effect on the activity of post-heparin esterase *in vivo*[11]. It may therefore be concluded that heparin produces an increase of esterase in the blood-stream, but that it does not form a component part of the molecule of this enzyme. As

opposed to this, lipoprotein lipase contains heparin or a similar substance, which explains its inhibition by protamine *in vitro* and its destruction by heparinase[12].

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Interaction of Gibberellic Acid and Photoperiod on the Vegetative Growth of *Pinus elliottii*

Conifers have not been very responsive to treatment with gibberellic acid. A definite stimulation of extension growth was obtained by Marth *et al.*[1] in only two of the five species investigated, *Pinus virginiana* Mill., and *Juniperus chinensis* f. *Pfitzeriana* Spaeth. Measurable, but not significant, increases in height growth of treated *Pinus strobus* L. have been reported[2]. Radicles of germinating seeds of *Pseudotsuga menziesii* (Mirb.) Franco elongated more rapidly if wetted with weak solutions of gibberellic acid[3].

The effect of this chemical on stem growth has generally been tested under natural photoperiod or under long days. The results presented here indicate that gibberellic acid promotes the growth of slash pine, *Pinus elliottii* Engelm., only under short-day conditions.

Shortly after emergence in February 1957, the pine seedlings were submitted to one of the following photoperiods: 8, 16 and 24 hr.; and natural day-length. The supplementary light was provided by incandescent bulbs giving an intensity of about 20 foot-candles at the level of the plant tips. Shoot elongation increased with increasing photoperiod. After four months, the average height of the seedlings under short days (8 hr.) was equal to 44 per cent of those in continuous light, whereas the 16-hr.-day plants were 70 per cent as high. Even in continuous light, slash pine elongates by flushes of growth, once it has formed secondary needles. The short-day seedlings produced only two flushes separated by a long time-interval. Practically no growth in height occurred in these seedlings between June and December. Starting then, half of them were sprayed, once every 14 days, with a 0·1 per cent aqueous solution of 'Gibrel' (potassium gibberellate) to which a few drops of a wetting agent had been added. Prior to spraying, the plants were slightly wounded by breaking off several primary needles to facilitate penetration of the chemical. The controls were subjected to the same mechanical injury.

Fifteen days after the first application, the terminal buds of several seedlings were swollen and had elongated slightly. One week later, 14 out of 25 treated plants had broken dormancy, and, one month after the initiation of the treatments, they were all actively growing. Most control plants began to break dormancy shortly after the treated plants but their height-growth lagged and stopped earlier. By May 15, the treated seedlings had grown an average of 67 mm. (52 per cent of initial height), significantly more than the controls (30 mm., or 24 per cent of initial height).

Gibberellic acid was also applied, as a spray and in a 1 per cent lanolin paste, to seedlings growing under natural and 16-hr. photoperiods and in continuous light. There was a small, but not significant, increase in average height-growth in natural day-length (11–12 hr. at that time), but no response was observed under long days.

In another experiment, four-month-old seedlings, that had been growing actively under 16-hr. days, were submitted to 8-hr. days in order to induce dormancy. This condition was obtained in 2–4 weeks. Gibberellic acid sprays were then administered at weekly intervals. The first signs of growth resumption appeared one month after the first treatment. Three months later, the forty treated plants had elongated by 26 mm. on the average, or 16 per cent of initial height, whereas the controls produced new needle fascicles but very little shoot-growth (8 mm. on the average, or 5 per cent of initial height). Seedlings of the same age submitted to long days showed no detectable response to the chemical.

It seems that, in slash pine, gibberellic acid is able to break the type of bud dormancy induced by short-day treatment, and to stimulate the growth of elongating shoots exposed to short photoperiods. The lack of response to the chemical in the long-day treatments suggests that the natural gibberellin factor becomes deficient, in this species, only under short days. In contrast to slash pine, two other conifers, *Pinus coulteri* D. Don and *Pseudotsuga macrocarpa* (Vasey) Mayr, did not respond to gibberellic acid under short days (while *Camellia japonica* L., an evergreen angiosperm, reacted positively)[4].

Interactions between gibberellic acid and photoperiod have also appeared in a preliminary study on bud-break in deciduous species. In some of these (for example, *Acer platanoides* L.), the chemical hastened bud opening to a greater extent under short days than under long days.

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Cocoa Shade and Manurial Experiment in Ghana

CONTRARY to general experience with other world crops, cocoa grown in West Africa had never been shown to respond to fertilizer, for reasons discussed by T. N. Hoblyn[1]. The recent successful control of capsid pests and the availability of uniform cocoa, however, has now made accurate experimentation possible.

In October 1956, at this Institute an area containing ten-year-old Amelonado trees planted in straight lines at 8 ft. × 8 ft. under uniform *Gliricidia maculata* shade (24 ft. × 24 ft.) was chosen for shade removal and fertilizer application. The trees were in their third year of bearing and pre-treatment records were available. Fifteen plots, each containing 300 trees, were marked out. The treatments applied were: original shade/no fertilizer; original shade/fertilizer mixture; no shade/no fertilizer; no shade/fertilizer mixture. All treatments are replicated three times, each replicate having 300 trees, thus making a total of 3,600 experimental trees. The three extra plots form guard plots between shaded and unshaded cocoa.

The fertilizers were broadcast by hand, and the types, rates and times of application are shown in Table 1.

Table 1

Application	Date	Fertilizer used in mixture	Rates (lb./acre)			
			N	P_2O_5	K_2O	MgO
1	Oct. 1956	Ammonium phosphate (11 per cent N, 46 per cent P_2O_5) Single superphosphate (18 per cent P_2O_5) Sulphate of potash (48 per cent K_2O) Magnesium sulphate (16·2 per cent MgO)	13	91	90	46
2	April 1957	Urea (46 per cent N) Triple superphosphate (47 per cent P_2O_5)	50	30	—	—
3	Sept. 1957	Urea	50	—	—	—

The shade was removed from all the non-shaded plots by poisoning the shade trees with 'Phortox' in March–April 1957.

The yields, expressed in pounds dry cocoa per acre, after one year of treatment are given in Table 2.

Table 2. YIELDS EXPRESSED IN LB. DRY COCOA/ACRE

Treatments	First fertilizer mixture applied October 1956. Shade removed March 1957. Pretreatment yields			After treatment yields
	1954–55	1955–56	1956–57	1957–58
Original shade/no fertilizer	30	44	205	615
Original shade/fertilizer mixture	24	32	211	869
No shade/no fertilizer	19	29	170	1,079
No shade/fertilizer mixture	20	18	173	1,574

Shaded/fertilized, unshaded/fertilized and unshaded/unfertilized treatments all showed significant increases in yield compared with the shaded/unfertilized control when an analysis of covariance was carried out. It is realized that one year's results are not sufficient to provide any definite general conclusions; but the sparsity of published information about the responses of cocoa to such treatments, especially in West Africa, has caused us to report these preliminary results. Fuller details of the investigations will be published elsewhere.

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Inheritance of Photoperiodic Reaction in Rice

Aus (summer) and *Aman* (winter) are the two important types of rice cultivated in Bengal, north-east India. The majority of the varieties of summer rice are photo-indifferent (period bound), while all the winter varieties are short-day (season bound) plants[1,2].

In practice, both summer and winter varieties are sown at the same time, at the beginning of the rice season in May–June, when the advent of rains ensures plenty of moisture required for good growth of the crop. The summer varieties, which are photo-indifferent, flower about 90 days after sowing and are ready for harvest in another month, in September. The winter varieties, which are short-day plants, do not flower until the length of the day decreases to less than 11·5 hr., in October–November. These varieties are harvested in November–December. As a rule, however, the winter varieties are much heavier yielders and better in grain quality than the summer varieties. It is of interest, therefore, to elucidate the inheritance of photoperiodic reactions in summer and winter rice, with the view of combining the early harvesting of the summer varieties with the high yield and good grain qualities of the winter varieties.

Reciprocal crosses were therefore attempted during the season of 1956 with plants, grown in pots, of two summer varieties, namely *Charnock* and *Dhairal*, and two winter varieties, namely, *Patnai*–23 and *Bhasamanik*, there being in all eight different combinations of crossings.

The combinations employed, the number of crosses actually attempted, the numbers of seeds gathered and of seeds germinating in the following season, and the number of plants showing hybrid characters under the respective combinations are shown in Table 1.

For these crosses flowering coincidence was effected in two ways. First, flowering of the winter varieties was hastened by short-day treatment to coincide with flowering of the summer varieties in their normal season. Secondly, a series of sowings of the summer varieties was made at fortnightly intervals until the end of August, to obtain coincidence of their flowering

Table 1

♀ Parent	♂ Parent	No. of flowers cross-pollinated	No. of seeds produced	No. of seeds germinated	No. of plants showing hybrid (F_1) characters
(1) *Bhasamanik*	× *Dhairal*	44	15	14	1
(2) *Dhairal*	× *Bhasamanik*	37	8	5	1
(3) *Patnai*-23	× *Dhairal*	18	9	9	2
(4) *Dhairal*	× *Patnai*-23	31	9	9	1
(5) *Bhasamanik*	× *Charnock*	33	6	4	1
(6) *Charnock*	× *Bhasamanik*	16	1	0	0
(7) *Patnai*-23	× *Charnock*	29	8	7	0
(8) *Charnock*	× *Patnai*-23	45	7	5	4

Table 2

Parent varieties	Time taken from sowing to flowering (days)	Height (cm.)	Tillering (No.)	Grain yield: Weight (gm.)	Grain yield: No. (approx.)
(1) *Patnai*-23 (winter var.)	188·1 ± 2·6	124·4 ± 3·3	8·6 ± 0·6	3·2 ± 0·3	125
(2) *Bhasamanik* (winter var.)	184·4 ± 2·9	106·8 ± 1·6	10·3 ± 0·7	2·5 ± 0·1	175
(3) *Charnock* (summer var.)	92·8 ± 0·7	94·3 ± 2·5	5·7 ± 0·8	2·8 ± 0·4	180
(4) *Dhairal* (summer var.)	87·6 ± 0·6	93·4 ± 1·8	3·9 ± 0·4	3·3 ± 0·4	125
F_1 Hybrids					
(1) *Patnai*-23 ♀ × *Dhairal* ♂	144·0	125·0	12·0	6·9	250
(2) *Patnai*-23 ♀ × *Dhairal* ♂	136·0	145·5	11·0	22·2	850
(3) *Dhairal* ♀ × *Patnai*-23 ♂	136·0	143·5	18·0	15·5	550
(4) *Bhasamanik* ♀ × *Dhairal*-23 ♂	138·0	130·0	25·0	16·9	800
(5) *Dhairal* ♀ × *Bhasamanik* ♂	139·0	119·5	21·0	6·2	300
(6) *Charnock* ♀ × *Patnai*-23 ♂	135·0	134·0	18·0	13·3	600
(7) *Charnock* ♀ × *Patnai*-23 ♂	136·0	136·0	15·0	18·5	850
(8) *Charnock* ♀ × *Patnai*-23 ♂	136·0	135·0	10·0	6·95	300
(9) *Charnock* ♀ × *Patnai*-23 ♂	137·0	138·0	11·0	8·9	350
(10) *Bhasamanik* ♀ × *Charnock* ♂	142·0	119·0	19·0	10·7	600

with that of the winter varieties in the normal season of the latter. The 'paper-bag' method was employed for opening flowers for emasculation[3].

In the season of 1957 the hybrid seeds were grown in pots to study their behaviour. Information on tillering, height, leaf size, flowering time and yield per plant was collected. Hybrid plants have been obtained from six of the eight combinations of crosses. Growth, flowering-time and yield of the hybrid plants, together with those of plants belonging to the parent varieties sown at the same time in 1957, are shown in Table 2.

The F_1 plants with all combinations of crosses show an intermediate effect on photo-periodic reaction, their flowering time being intermediate. The reciprocal crosses were identical.

In respect of growth characters, such as height, tiller number and yield, the F_1-hybrid plants of all six different combinations of crosses display hybrid vigour.

Further work is in progress.

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A New Species of *Azotobacter* producing Heavy Slime and Acid

In the course of an investigation on the geographical distribution of the Azotobacteriaceae[1] in various types of soil in India, a nitrogen-fixing organism has been isolated from a sample of red soil from Pattambi (Madras) by Winogradsky's silica-gel plate technique and purified by dilution platings. This new bacterium differs in certain morphological and physiological characteristics from known species of *Azotobacter* (including *Beijerinckia*)[1]. The cells are oval in shape, occur mostly in pairs and packets and sometimes singly, measuring on an average 1·2–2·2μ × 2·3–4·6μ (Fig. 1). The cells do not change their shape even on prolonged incubation in Ashby's nitrogen-free liquid medium with different carbohydrates. The bacterium encysts after 30 days incubation at 30° C. in the solid mannitol medium without calcium carbonate. The optimum temperature for growth was found to be about 30° C.

The colonies are usually raised, oval or circular and sometimes elongated with an average diameter of 2·95 mm. × 1·55 mm. on Ashby's nitrogen-deficient agar medium after 10 days incubation at 30° C. Colonies are transparent at first and gradually become opaque and sometimes curled if the medium is devoid of calcium carbonate. In streak cultures, the organism forms a slimy growth of variable thickness. In Ashby's nitrogen-free glucose or sucrose medium without calcium carbonate, the slimy masses at first accumulate on the surface of the medium, which is entirely transformed to a jelly-like consistency in about one month. Slime production is always associated with the growth of the organism. With calcium carbonate present in the medium, however, growth is depressed to some extent.

The organism is aerobic, non-motile, and the cells are Gram-negative. It produces no colour even on addition of a small amount (10γ per litre) of copper sulphate in Ashby's nitrogen-deficient agar medium[2], but some rust-brown sediment occasionally occurs in the nitrogen-free solid medium after six weeks incubation at 30° C. This sediment does not dissolve in alcohol, ether or chloroform.

The bacterium is usually resistant to certain basic aniline dyes, namely, crystal violet, gentian violet, safranine and methylene blue. However, staining is accomplished when the dyes are mordanted with phenol or aniline. The cells are stained by both basic carbol-fuchsin and aniline gentian violet on slight warming.

This bacterium produces acid from all the carbohydrates in nitrogen-free medium, especially glucose, sucrose, mannitol, starch, galactose, raffinose, mannose, maltose and dextrin. The development of acidity is the quickest in glucose, and is delayed

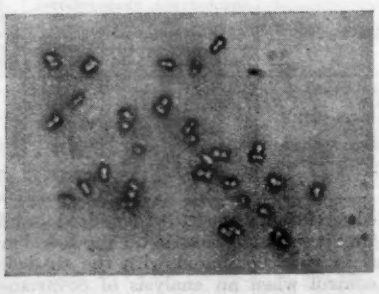

Fig. 1. *Azotobacter acidum*: a new species of *Azotobacter* producing heavy slime and acid. (× 500)

much in mannitol. Growth ceases when the *p*H of the medium falls below 4·0.

The organism fails to grow in organic sources of nitrogen, but with inorganic nitrogen (both with NH_4^+ and NO_3^-) the growth is accelerated with a rapid fall of *p*H and it ceases to grow after 10 days at 32° C. The bacterium does not grow either in nutrient broth or in peptone agar containing 0·5 per cent glucose. No gas is evolved during break-down of carbohydrates. In potato slants, cream-coloured growth appears in 4 days at 30° C. The organism can hydrolyse starch, and good amylase activity is observed after 6 days incubation at 30–32° C. It does not liquefy gelatine and produces no change in litmus milk during a period of 3 weeks at 30–32° C. The bacterium does not form indol or acetyl-methyl carbinol. It neither reduces nitrate nor produces ammonia.

The bacterium fixes on an average 8–10 mgm. of nitrogen per gram of glucose or sucrose added in Ashby's nitrogen-free solution without calcium carbonate after 3 weeks incubation at 32° C.

The organism differs from *Az. chroococcum* and *Az. beijerinckii* in that it forms acid from different carbohydrates and withstands acidity up to *p*H 4. Moreover, it produces no colour even on addition of copper sulphate. The cells are smaller and do not form streptococcus-like chains. The bacterium differs from *Az. agile* and *Az. vinelandii* in that it lacks motility; it fails to grow in nutrient broth even with glucose and it does not form any fluorescent green pigment. Unlike *Az. indicum*, the cells lack fats and form cysts in the solid nitrogen-free carbohydrate medium. In Ashby's nitrogen-free medium with dextrin, *Az. indicum* fails to grow, while the new organism shows good growth. *Az. indicum* produces turbidity in the liquid medium with the formation of some sediment, but the new organism gradually changes the consistency of the medium to a semi-solid.

The differences between the morphological and cultural characters of the bacterium described here and other known species of *Azotobacter*[3] indicate that the organism is a new species. It is proposed that it should be named *Azotobacter acidum*, due to its property of forming acids from carbohydrates. Details of this work will be published elsewhere.

I am indebted to Dr. B. C. Kundu, director, and Dr. M. K. Mukherjee, chemist, Jute Agricultural Research Institute, for their help and encouragement.

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A New Type of Early Cysticercoid Stage in a Cyclophyllidean Cestode

Cysticercoids of various cyclophyllidean families are known to occur in small invertebrate hosts, commonly in arthropods and very occasionally in molluscs and annelids. During the course of some work on the pulmonate snail, *Oxychilus cellarius* (Müll) one of us noted a 3 per cent infection of the peritoneum around the digestive gland and gut with cysticercoids of what we believe to be a member of the Dilepididae, the first such record from a mollusc. The cysts numbered from one to about fifty in a single specimen and were seen in various stages of development, ranging from what we consider to be the pre-cystic stage to the fully formed, infective cysticercoid. The older cysticercoids with completely formed scolex and bladder resemble very closely the corresponding stage of another cysticercoid of the Dilepididae—that of *Choanotaenia infundibulum* (Bloch) described by Reid and Ackert[1]. A full account of these stages will be published later, but meanwhile we wish to direct attention to the earliest stage of this cysticercoid—a form which we regard as being pre-cystic and which, so far as we are aware, is unlike anything previously described.

From some of the younger cysts, the walls of which are adventitious host structures formed from peritoneum surrounding the parasite, tailed larvæ (Fig. 1) were extracted which were quite actively mobile in saline, bearing a marked resemblance in their movements to digenetic cercariae. We think that such a form must have been only very recently encysted, having reached its position by movement of the tail. Mobile, tailed larvæ of this kind have been reported only twice before in the Cestoda, in each case in the life-cycle of *Dipylidium caninum* L. by Grassi and

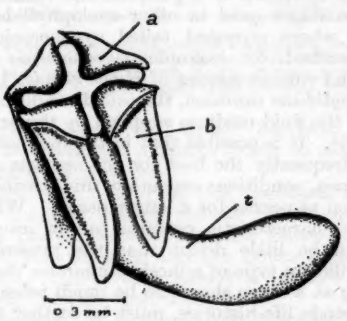

Fig. 1. Pre-cystic stage drawn from living specimen. For key see Fig. 2

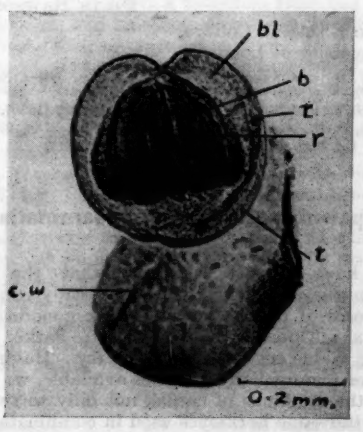

Fig. 2. Photograph of early cysticercoid stage with tail still present and bladder formed.

Figs. 1 and 2. Key: *a*, auricular appendage; *b*, bothridium-like adhesive organ; *bl*, bladder; *c.w*, cyst wall; *r*, retracted rostellum with double coronet of rose-thorn-shaped hooks *t*, tail

Rovelli[2] and Vennard[3]. The former writers compared its movements with those of cercaria, and Janicki[4] quotes this as part of the evidence for his 'Cercomer theory' in which he attempts to explain a possible derivation of the cestodes from the Digenea.

The tailed larva in the present work differs from any other tailed cysticercoid now known, either encysted or free, in possessing, instead of typical acetabula, four elongated muscular adhesive organs which resemble the bothridia of the Tetraphyllidea. It is not possible at present to say whether these structures are true bothridia or whether they are clearly demarcated at this stage from the rest of the scolex musculature, but they rapidly become acetabular by definition while still bothridia-like in shape, in the developing cysticercoid (Fig. 2). In the earlier stage (Fig. 1) each bothridium-like structure bears anteriorly an auricular appendage similar to those in the plerocercoid and adult of the tetraphyllidean *Dinobothrium plicitum* Lint. and also those of adult Tetrabothrioidea. As the cysticercoid approaches the infective stage, however, the whole muscular organ (bothridium-like structure plus its auricular appendage) resolves itself to form an acetabulum like that of typical Cyclophyllidea.

Whether or not this larva establishes affinity with the Digenea or Cestodaria or both must still be a matter of opinion; it is possible that similar tailed pre-cystic stages exist in other cyclophyllidean life-histories where encysted tailed cysticercoids have been described, for example, *Choanotaenia infundibulum* and various species of *Hymenolepis*. In these, as in *Dipylidium caninum*, the tailed condition would relate to the fluid medium supplied by the arthropod hæmocœle. It is possible that in the mollusc, which is most frequently the host for the cercaria stage of the Digenea, conditions encourage this possible larval adaptation to persist for a longer period. Whichever way the characteristic cercaria tail is interpreted, there can be little doubt that the presence of a tetraphyllidean type of adhesive organ on the scolex, occurring at a stage shown to be much telescoped in other cestode life-histories, must be further evidence of the tetraphyllidean origin of the Cyclophyllidea.

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Spawning Catfish with Mammalian Hormones

We have already reported[1] that the catfish (*Heteropneustes*, *Clarias*) available locally respond to large doses of mammalian chorionic gonadotrophins ('Physex': Dumex; 'Antuitrin *S*': Parke, Davis), yielding viable eggs hatching into fry. Having tried the other mammalian hormones available, we wish to record the reactions of catfish not only to them but also to the same hormones used in combination with a threshold dose (*vide infra*) of catfish pituitary gland. In discussing the action of mammalian hormones, Hoar[2] stated that ". . . fish are so unresponsive to many mammalian (and bird) preparations that it is generally impractical to use them. The fish culturist or physiologist who wishes to hasten gonad development in fish is advised to use fish pituitaries". However, Kirshenblat[3] secured viable eggs of *Misgurnus* using methyl testosterone, progesterone and deoxycorticosterone acetate.

Heteropneustes (*Saccobranchus*) usually breeds during July–September, the monsoon months in South India. During February and March, growing ova are noticed in them and the ovary is in stage 4 according to the international maturity scale. We have found that a homoplastic parenteral injection of a dose equal to one-eighth of a gravid pituitary gland does not affect the ovary greatly; the catfish do not spawn and on stripping they yield few ripe eggs. This, therefore, may be taken as a dose to prime the ovary and used as the threshold dose to study the synergic action of the mammalian hormones injected into catfish. A homoplastic injection of a quarter gland of *Heteropneustes* pituitary makes them yield a large number of ripe eggs.

Mammalian follicle-stimulating and luteinizing hormones (Armour Laboratories, Chicago) have caused *Heteropneustes* to spawn and yield a large number of viable eggs[4]. The response of the fish to the follicle-stimulating hormone is obviously due to the small amount of luteinizing hormone present in it; this was afterwards confirmed by Dr. I. Bunding (Armour Laboratories, Chicago). He also stated (*in lit.*) that American minnows could not be made to spawn with similar mammalian gonadotrophic hormones sent to us. Hasler and Meyer[5] also failed to cause goldfish to spawn with purified mammalian luteinizing hormone; the fish also proved refractory, at certain dosage levels, to some mammalian pituitary suspensions[6]. Pregnant mare serum ('Antex': Dumex), œstrogen and progesterone have failed to make catfish spawn[1] and we have now found that methyl testosterone (Boots; 'Perandren' linguets: Ciba), deoxycorticosterone acetate ('Corlin': Glaxo), adrenocorticotropic hormone ('Adrenomone': Armour), growth hormone ('Somar': Armour) and oxytocin (Parke, Davis) are also ineffective in ripening the eggs of *Heteropneustes*. Kawamoto[7] tried unsuccessfully to obtain viable eggs from *Ctenopharyngodon* using sex hormones. On the other hand, catfish receiving a 2·5-mgm. dose of thyroid-stimulating hormone (Armour Laboratories) yielded viable eggs on stripping. This is probably the first instance where the thyroid-stimulating hormone has been used successfully for ripening fish ova. Pickford[8] indicated that thyroid activity may be necessary for gonad maturation, but there is no reference, so far as we are aware, to the use of thyroid-stimulating hormone as an ovulating agent.

We have therefore tried the other mammalian hormones in combination with a threshold dose of *Heteropneustes* pituitary gland. When gravid catfish are injected with a threshold dose equal to one-eighth of a pituitary gland combined with growth hormone, œstradiol dipropionate ('Ovocyclin *P*': Ciba), progesterone ('Proluton': Schering) and methyl testosterone respectively, the test animals gave many ripe and a large number of over-ripe eggs when stripped. Test animals receiving pregnant mare serum (75 I.U.), adrenocorticotropic hormone (10 U.S.P. units) and oxytocin (5 I.U.) respectively in combination with the threshold dose did not yield ripe eggs.

Two important points emerge from our bioassays. First, thyroid-stimulating hormone has been found to be an ovulating agent. Secondly, growth hormone,

oestrogen, androgen and progesterone act as synergic agents when used along with a threshold dose of catfish pituitary gland, whereas pregnant mare serum, adrenocorticotropic hormone and oxytocin are ineffective.

Details of these experiments will be published in the *Journal of Scientific and Industrial Research*, New Delhi.

We wish to thank Prof. B. R. Seshachar for encouragement; Dr. I. Bunding (Armour Laboratories, Chicago) and Ciba Pharma Private Ltd., Bombay, for generous help with mammalian hormones and one of us (A. B. L.) is indebted to the Council of Scientific and Industrial Research, New Delhi, for the award of a scholarship.

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A Lungfish (*Protopterus*) from the Middle Zambezi

The Joint Fisheries Research Organization has been so fortunate as to acquire a lungfish from the Middle Zambezi. The specimen came, on May 15, 1957, from a stagnant 'backwater' of the Zambezi, at that time receding from its peak flood, in the Chipepo district on the northern bank, and was collected by Mr. Thayer E. Scudder, an anthropologist, who was at the time studying the local Gwembe Tonga people. Notwithstanding the fact that several fish-collecting expeditions have been made to this area, which is due shortly to be flooded by the waters of the Kariba dam, no other specimens are known from this region. However, it is known to the natives, who call it 'Ikana'. The fish is a specimen of *Protopterus annectens* (Owen), typically light-coloured ventrally, with the belly and lower head covered with conspicuous dark spots, and is of considerable interest in many respects.

This is the first record of a lungfish from the Middle Zambezi system, which is faunistically divided from the Upper Zambezi by the Victoria Falls and the Lower Zambezi by the Kebrabassa rapids, so that each section of this great river has a characteristic fish-fauna. The Middle Zambezi may in general be regarded as intermediate in that, while it has itself few distinct species, the characteristic fishes of the Upper Zambezi, such as *Hemichromis fasciatus*, *Sarcodaces odoë*, *Tilapia macrochir*, etc., derived presumably from the Congo, and those occurring in the Lower Zambezi such as certain chondrichthyans, gobiids, ambassids, syngnathids, etc., which are derived from marine or estuarine faunas, are alike absent from it. Lungfishes have still not definitely

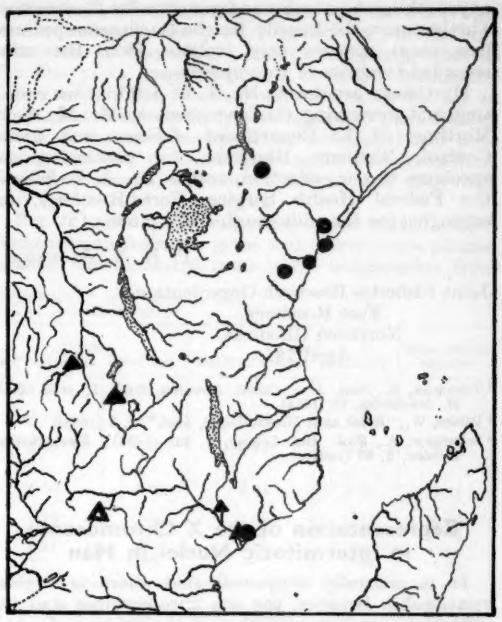

Fig. 1. Sketch map illustrating recorded occurrence of *Protopterus annectens* (▲), and *P. amphibius* (●), in East Africa and the Zambezi and Congo Basins. The locality of the new record is indicated by an open triangle (after Trewavas, ref. 1)

been recorded from the Upper Zambezi, though enough circumstantial evidence exists to make their occurrence there probable.

Secondly, the locality of this specimen is intermediate between known records for *P. annectens* from the Lower Zambezi and the Lower Shire on one hand, and Katanga and the Lower Luapula on the other[1]. The present record is marked on the map of Fig. 1 as an open triangle.

A radiograph of the specimen revealed a third point of interest, namely, that it has only 32 pairs of ribs. According to Trewavas's recent study[1], it resembles in this respect a specimen from the Lower Shire (33 pairs) and Katanga specimens (32–33 pairs), while West African specimens have 34–37 pairs. Trewavas reasserts the specific distinctness of *Protopterus amphibius* (Peters), based on studies of material from Kenya darker, more thickset and with fewer ribs (27–29 pairs) than *P. annectens*. While the specific distinctness of this material is not to be doubted, the specific name *amphibius* was originally proposed by Peters[2] (*Rhinocryptis amphibia*) for specimens collected from Quelimane. Most of these have since proved to be *P. annectens*, and while one cannot as yet be certain on this point, it seems at present difficult to believe that there are two species of *Protopterus* in the Zambezi delta as maintained by Schneider[3]. There the species is based on one specimen stated to have 30 pairs of ribs, a number greater than that found in the Kenya specimens, and

Table 1

Total length (mm.)	278	Pelvic fin length (mm.)	76
Snout-vent length (mm.)	145	Pectoral fin-membrane width (mm.)	1·5
Snout-dorsal fin length (mm.)	77	No. of external gills	3
Head length (tip of snout to top of gill-opening) (mm.)	42	Longest gill length (mm.)	15
Head-width (mm.)	30	No. of scales (gill-opening to pectoral fin)	46
Pectoral fin length (mm.)	92		

approaching the number so far known for *P. annectens*. Furthermore, the locality for the Quelimane specimen (see map) appears very isolated from the other recorded localities of *P. amphibius*.

My thanks are due to Mr. T. E. Scudder for collecting and preserving this specimen, to Mr. M. A. E. Mortimer of the Department of Game and Tsetse Control, Northern Rhodesia, for presenting the specimen to our collection, and to Dr. A. C. Ellis of the Federal Health Service, Fort Rosebery, for arranging for the radiograph to be made of it.

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Representation of the *X* Chromosome in Intermitotic Nuclei in Man

It is generally supposed[1] that there is a close relationship between the sex chromosomes and the nucleoli in most species, though the evidence for this in mammals is scanty[2]. It is nearly certain that the sex chromatin body[3] found in most nuclei in females of some species, including man, represents the heterochromatin of the *X* chromosome pair[4]. The demonstration of a persistent connexion between these bodies in some nuclei may serve to support both hypotheses. Reitalu[5] has described such a connexion in human fœtal liver; the matter seems important enough to justify this further description, based on observations, made in ignorance of Reitalu's, of similar structures seen elsewhere.

Thyroid tissue cultures offer exceptionally favourable material for the study of nuclear detail. We have used the primary outgrowths from fragments of human thyroid removed at operation, attaching the fragments to coverslips with plasma clot. In such preparations mitoses are rare, and most of the cells seen appear to be epithelial migrants from the original explant. Sex chromatin may be seen in as many as 90 per cent of nuclei. The nucleolar chromocentres are large and variable in number as well as size, though two is the commonest number. A well-defined strand of chromatin joining the sex chromatin to these chromocentres (Figs. 1, 2) is seen in perhaps 1 per cent of the cells. It is usually sinuous in its course and may bear one or two small chromatin granules; we have not been able to satisfy ourselves that it is clearly double in the manner of Reitalu's drawings. It is demonstrable only with difficulty in other material, but Fig. 3 shows a very clear example in a decidual cell from an abortion. Klinger's[6] illustrations (especially his Fig. 7) suggest that similar threads might be demonstrated in human amnion or chorion.

Reitalu describes this strand as a euchromatin thread joining two heterochromatin bodies. The heterochromatin of the sex chromatin must lie in the unpaired segment of the *X* chromosomes. We have failed to demonstrate any sex difference in the nucleolar chromocentres in several tissues, and conclude that they probably represent heterochromatin of the paired segment. These three linked structures must therefore represent a substantial part of the *X* chromosome, visible in the resting nucleus.

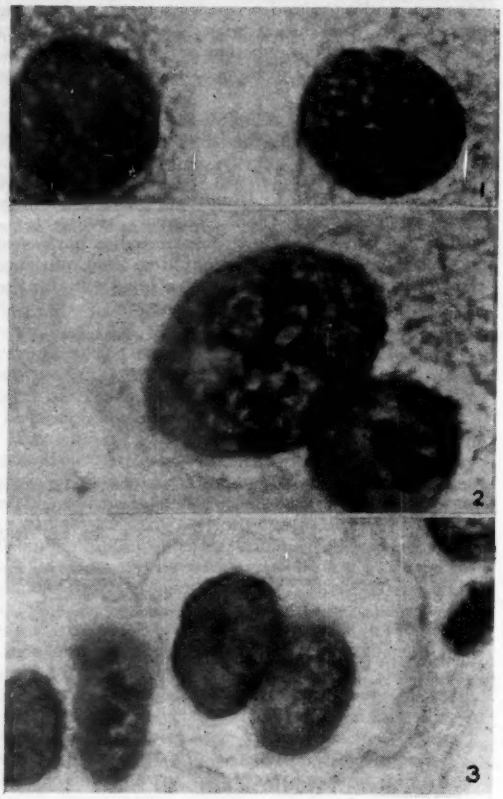

Fig. 1. Two nuclei from a thyroid tissue culture (female). On the left, the euchromatin thread is seen as a thick relatively ill-defined strand running down and to the right from the sex chromatin (at 12 o'clock) to join the right hand of the two nucleolar chromocentres. On the right, the euchromatin thread is very well defined, though its last part is out of focus: it runs from the sex chromatin (at 12 o'clock) to the left hand of the three nucleolar chromocentres. (Cresyl echt violet, × 2,000)

Fig. 2. An unusually fine and well-defined euchromatin thread, running from the sex chromatin (at 3 o'clock) straight to the nearest of the three nucleolar chromocentres. (Feulgen, × 2,000)

Fig. 3. Decidua from an abortion. A well-defined euchromatin thread running from the sex chromatin (at 4 o'clock on the nucleus of the central cell) to the nearest chromocentre. (Feulgen, × 2,000)

One of us (D. M. S.) acknowledges with thanks a grant from the Friends of the Hebrew University of Jerusalem.

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Evapo-transpiration from Different Crops exposed to the Same Weather

PENMAN[1] has concluded from a physical analysis of the process of evaporation that the rate of evapo-transpiration is the same for different crops exposed to the same weather provided that each crop covers the ground completely and is approximately of the same colour. Rider[2], however, has concluded from microclimatic measurements made above extensive areas of different crops that these can so modify the effective weather that large differences in the water loss from different crops can occur.

The evapo-transpiration from grass and carrots was measured at the crop weather station, Wellesbourne[3], continuously from mid-June until early October 1957 in the centre of plots 600 square yards in area. There were two soil-moisture treatments; in one the plants were irrigated each day to restore the soil to field capacity and in the other the plots received only rainfall. Each measurement was based on the mean of the readings from three similar lysimeters. The lysimeters used to measure evapo-transpiration in the plots supplied by rainfall only consisted of weighable monolith soil cores, whereas for the plots irrigated daily, drainage lysimeters[4] were used. The twelve lysimeters were buried to their rims and completely surrounded by plants which received the same soil-moisture treatment and were similar in size to those growing in the lysimeters. The instruments were tested before and after use and found to be water-tight.

Fig. 1 shows the measured cumulative evapo-transpiration from the grass and carrot crops plotted against the measured cumulative evaporation from a standard evaporation tank. The relation was linear in each case. The use of the evaporation tank readings as an index of the evaporative conditions is supported by the close agreement between the measured evaporation and that estimated by Penman's method[1].

Table 1. ENERGY BALANCE, WELLESBOURNE (JUNE 6–OCTOBER 1, 1957)
Energy expressed as in. of water (1 in. = 1,500 gm.cal.)

Measurement	Method	Grass		Carrots		Open water surface
		Daily irrigation	Rain only	Daily irrigation	Rain only	
Short-wave sun and sky radiation	Measured by Kipp solarimeter	18·54	18·54	18·54	18·54	18·54
Heat storage change	Calculated from temperature and moisture measurements	0·16	0·18	0·14	0·16	0·24
Long-wave radiation	Calculated from temperature, humidity and hours of sun	5·34	5·34	5·34	5·34	5·34
Albedo	Calculated from measurements of visible albedo with infra-red albedo taken as 45 per cent	5·56	5·56	4·64	4·64	1·11
Growth	Calculated from measurements of dry weight and energy equivalent	0·10	0·07	0·38	0·17	0·00
Evapo-transpiration	Measured (see text)	9·04	5·89	12·88	7·65	8·82
Heat transfer: from air to crop	Calculated by subtraction	1·34	—	4·56	—	—
" from crop to air		—	1·86	—	0·90	3·51

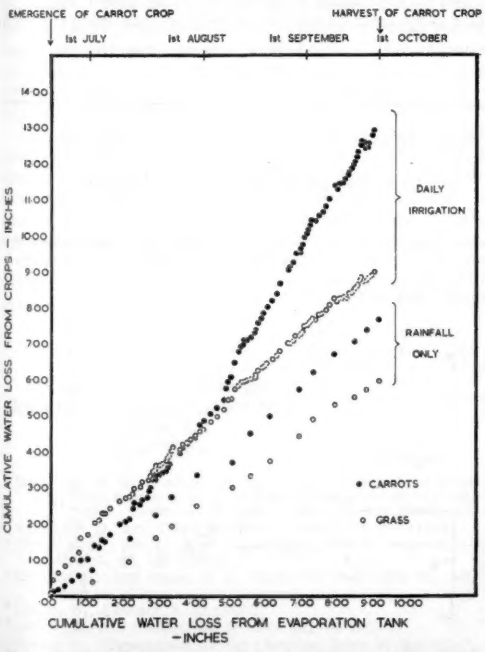

Fig. 1. Effect of crop type and soil moisture treatment on relative rate of evapo-transpiration

After the irrigated carrots had covered 40 per cent of the ground surface there was an alteration in the slope of the linear relation between evapo-transpiration from the crop and evaporation from the water tank (top line, Fig. 1), and further increases in crop cover and height had no effect on the rate of evapo-transpiration. With both grass and carrots receiving only rainfall the rate of evapo-transpiration was reduced by 40 per cent as compared with those that were irrigated.

Meteorological observations enabled the energy balance to be calculated for the grass and carrot crops grown under the two soil-moisture treatments and for the open water surface of the evaporation tank.

The differences in the amount of evapo-transpiration from the two crops could not be explained by the differences in the amount of energy used for growth, heat storage or for reflexion, so that large differences must have occurred in the amount of heat transferred to and from the air.

Similar comparisons are now being made with other vegetable crops in order that the relation between evapo-transpiration and evaporation from an open water surface may be established for crops usually irrigated.

Grateful acknowledgment is made to Miss J. I. E. Rubio for taking most of the measurements.

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A Genetic Test for Side-chains in a Phage Chromosome

A NUMBER of authors[1] have proposed side-chain models of the chromosome. The chromosome, as suggested most recently by Taylor, consists of a double core or central backbone, with double deoxyribonucleic acid helices[2] attached at right angles. These double helices are connected to the core at specific attachment points so that one polynucleotide chain of each helix is attached to one half of the core and the other polynucleotide chain to the other half.

This side-chain model is of interest for a number of reasons. (1) Its double structure is compatible with the organization and duplication of chromosomes as revealed by the studies of Taylor, Woods and Hughes[3] using tritium-labelled thymidine. (2) Despite the calculations of Levinthal and Crane[4] suggesting the feasibility of unwinding long double deoxyribonucleic acid helices, unwinding and separation of relatively short deoxyribonucleic acid helices arranged as side-chains is more easily visualized. (3) Conventional crossing-over would take place along the central backbone, and additional recombinations could occur on the side-chains. (4) Negative interference and gene conversion can be explained in at least a formal manner by side-chains.

We have found no evidence for side-chains using a genetic test on bacteriophage *P22* of *Salmonella typhimurium*. The test could detect the occurrence of two loci on the same side-chain. The only requirement of the test is the presence of marker loci to either side of the two loci to be tested. The test is of general applicability and can be used with other organisms.

The wild type of *Salmonella typhimurium* phage *P22* is temperate. On infection, some bacteria may be lysed, but some may survive and give rise to lysogenic progeny. Lysogenic bacteria possess the ability to produce the infecting phage and are immune to subsequent infection by the phage or its mutants. Genetic control of the lysogenic condition lies in the prophage, which is presumed to be phage genetic material attached to the bacterial chromosome. Temperate phage *P22* produces plaques with turbid centres owing to the growth of lysogenic bacteria.

Phage *P22* mutates spontaneously to forms which produce plaques with clear centres. All mutants forming clear plaques can be classified into one of three phenotypic groups based on their ability to lysogenize[5]. These groups are called c_1, c_2 and c_3. The *c* mutations can be mapped genetically as three closely linked pseudoallelic series[6]. All the c_1 mutations fall in one series, all the c_2 mutations in a second, and all the c_3 mutations in a third. The mutations of each series are separable by recombination. These pseudo-allelic series behave like the functional units or cistrons of Benzer[7]. The alleles of the different series interact to give lysogeny, whereas the alleles of the same series do not. The *c* region is flanked by plaque-morphology loci. Fig. 1 summarizes the above in a linkage map. More complete descriptions of phage *P22*, its mutants and the methods and media used in their handling have been published elsewhere[5].

The *c* region was studied for evidence of side-chains. *Salmonella typhimurium* of strain *LT2* is grown to concentrations of about 10^8 cells/ml. in *L* broth. The cells are washed twice in buffered saline, resuspended in one-half the original volume and aerated for 45 min. at 37°. The cell concentration is then re-adjusted to 1×10^8 cells/ml. with buffered saline. Mixtures of *c* mutant stocks, one marked with plaque morphology mutations m_3 and h_{21} and the other with the wild-type alleles of these mutations, are submitted to adsorption for 5 min. A 1 : 10 dilution is made into *L* broth containing a concentration of anti-phage serum sufficient to inactivate 99 per cent of the unadsorbed phage in 5 min. Further dilutions are then made, and after 90 min. chloroform is added to kill any surviving bacteria. Diluted samples of phage progeny are plated on indicator agar for examination.

Only the rare turbid recombinants arising by a recombination between the closely linked *c* loci in region II (Fig. 2) need be considered. (The reciprocal double-mutant recombinants are not easily detected.) These turbid recombinants are examined for additional recombinations between the clear-plaque region and the m_3 locus to the left (region I, approximately 13 units long) and the h_{21} locus to the right (region III, approximately 7 units long). Four classes of turbid recombinants are expected. Based on the relative frequencies of these four classes, a distinction between a linear vs. side-chain model can be made.

Assuming a linear structure, the four classes in order of decreasing frequencies are as listed in Fig. 2*a*. The same four classes are expected, but with different

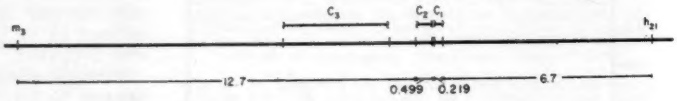

Fig. 1. Linkage map for phage *P22*

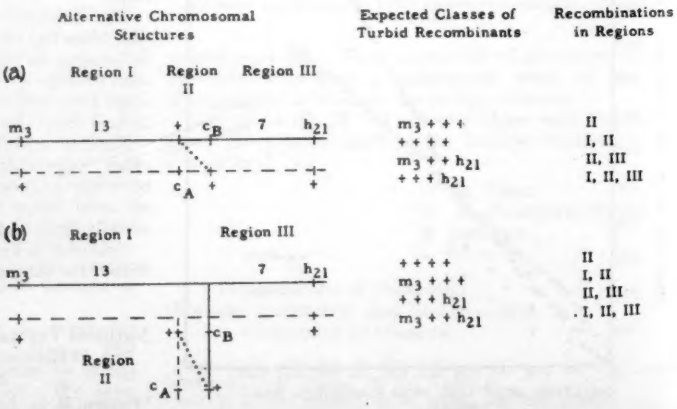

Fig. 2. Alternative chromosomal arrangements of the phage *P22* linkage map and the expected turbid recombinant classes. The dotted lines indicate the recombinations giving rise to turbid progeny

frequencies, if the *c* alleles are arranged on the same side-chain as shown in Fig. 2*b*. (Still different but distinctive frequencies of these four classes are expected should the order of the *c* alleles be reversed.)

The rather unlikely possibility that both the c_1 and c_2 cistrons are on the same side-chain was tested by the intercistron cross, $c_2^5 \times c_1^{49}$ (Table 1). The results are in agreement with the linear model: the $m_3{}^{+}{}^{+}{}^{+}$ class is the major class. The two most distantly linked mutant c_2 stocks c_2^5 and c_2^{37} were crossed, on the assumption that a side-chain can be equated to an entire cistron. Again the results are in agreement with a linear structure. Similar findings were obtained from crosses between more closely linked c_2 mutants (Table 1). Finally, crosses between alleles of the smaller c_1 cistron also support the linear model (Table 1).

Table 1. CROSSES BETWEEN *C* MUTANTS OF PHAGE *P*22

Crosses		Map distance between *c* mutations	Frequency of turbid recombinant classes (per cent)				Total turbid progeny
++ Parent	m_3h_{31} Parent		$m_3{}^{+}{}^{+}{}^{+}$	++++	$m_3{}^{+}{}^{+}h_{31}$	$+{+}{+}h_{31}$	
c_2^5	c_1^{49}	0·843	49·3	23·8	19·5	7·4	231*
c_2^5	c_2^{37}	0·499	47·8	20·5	23·6	8·1	395†
c_2^{33}	c_2^{37}	0·333	44·8	20·2	27·0	8·0	163
c_2^5	c_2^{33}	0·276	40·8	23·9	25·4	9·9	142
c_1^{45}	c_1^{53}	0·219	55·6	18·8	17·9	7·7	117*
c_1^{45}	c_1^{49}	0·149	58·8	17·8	16·1	7·3	124*

* Sum of two independent experiments.
† Sum of three independent experiments.

The results presented do not support the idea of two genes on the same side-chain. Conceivably, some support for this hypothesis might be forthcoming from crosses between more closely linked alleles than those mentioned above. Crosses between alleles as close as 0·067 map unit suggest that linearity is still the rule. The alternative hypothesis of individual loci on individual side-chains, while not ruled out by these experiments, seems improbable. The expectation that the double-recombinant classes would increase with decreasing distance between alleles is not borne out by the results.

The apparent lack of side-chains in a phage should not be taken as too damaging to the model. A most attractive aspect of Taylor's model is the possibility that prophage establishment is the attachment of phage deoxyribonucleic acid as a side-chain to open specific points on the bacterial chromosome.

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Analysis of Mixtures of Glucosamine and Galactosamine with Bakers' Yeast

STUDIES in this laboratory on the incorporation of carbon-14 precursors into corneal mucopolysaccharides necessitated the development of a method for the quantitative separation of labelled hexosamines in tissue hydrolysates. Other procedures[1-3] employing column chromatography for quantitative resolution were not suitable for the analysis of large numbers of samples. The specific fermentation by bakers' yeast of D-glucose but not D-galactose[4] and the reported phosphorylation of D-glucosamine by yeast hexokinase[5] suggested the possibility of employing whole bakers' yeast for the separation of the naturally occurring amino-sugars, D-glucosamine and D-galactosamine. Experiments with bakers' yeast revealed a quantitative removal of D-glucosamine, as measured by colorimetric procedures, and no detectable utilization of D-galactosamine. In the present communication, we wish to describe a procedure for quantitative analysis of mixtures of these two sugars. Slein[6] has reported the use of purified yeast hexokinase to distinguish between these hexosamines.

Tissue hydrolysates are first adsorbed and eluted from 'Dowex 50' (H+) resin columns in order to separate the amino-sugars from other carbohydrate components. The total hexosamine content is determined on an aliquot of these preparations by the Blix–Elson–Morgan procedure[7,8]. Another aliquot, containing up to 1 μmole of glucosamine, is placed in a volume of 1·5 ml. of water in a 25-ml. Erlenmeyer flask. 2 ml. of a yeast suspension (600 mgm. wet weight) is then added to each flask. The suspension is prepared by washing 15 gm. of *fresh* bakers' yeast (Fleischmann) four times with distilled water, with centrifugation at 4° C. between each washing. The yeast is suspended uniformly in 25 ml. of 0·1 *M* sodium phosphate buffer (*p*H 7·5) and brought to a volume of 50 ml. with water.

The stoppered flasks are incubated for 1 hr. in a constant-temperature shaker at 30° C. and 70 oscillations per min. After removing the yeast by centrifugation at 4° C., 1 ml. aliquots of the supernatant fluids are analysed for hexosamine. Centrifugation was usually repeated to ensure complete removal of the yeast. With each yeast run, a galactosamine standard (for example, 0·9 μmole) plus yeast is included in duplicate to correct for any losses by evaporation, for effects of phosphate on the colorimetric determination, and for possible non-equilibration with the large volume of yeast cells. A yeast control, which gives an optical density less than 0·01, and a glucosamine control (1 μmole) plus yeast also are included to ensure that there is complete removal of the glucosamine. More than 99 per cent of the glucosamine was removed with four different batches of fresh bakers' yeast. The commercial yeast is stable for several weeks when stored at 4° C.

The galactosamine content is calculated, employing the internal galactosamine standard, from the hexosamine concentration after yeast action. It is assumed that the extinction coefficients of glucosamine and galactosamine in the Blix test are identical[9,10]. The glucosamine content is calculated as the difference in hexosamine concentration before and after yeast action. Results of several analyses of synthetic mixtures and a comparative analysis of four blood group substances, kindly supplied by Dr. E. A. Kabat, are listed in Table 1. The limiting factor in the

Table 1. Analysis of Synthetic Mixtures of Amino-sugars and Blood-Group Substances

Added		Found	
Glucosamine (per cent)	Galactosamine (per cent)	Glucosamine (per cent)	Galactosamine (per cent)
0	100	0*	100*
50	50	50	50
76	24	74	26
20	80	21	79
37	63	35,35*	65,65*

Blood-group substances	Analysis by Leskowitz and Kabat (ref. 2)		Found*	
Hog, 16	57	43	58,57	42,43
Horse, 6–15 per cent	69	31	67	33
Saliva, W.H., 2–10 per cent	61	39	55	45
Horse, 5–25 per cent	53	47	45	55

* Samples were purified by adsorption on a 10-ml. column of 'Dowex 50' cation exchange resin (200–400 mesh, 12 per cent cross-linkage, H^+ form). The amino-sugars were completely adsorbed when placed on such columns in 2 ml. of 2 *N* hydrochloric acid. After washing the columns with water, the hexosamines were eluted with about 25 ml. of 0·75 *N* hydrochloric acid and lyophilized over silica gel–sodium hydroxide. The procedures described by Boas (ref. 8) and Roseman and Daffner (ref. 10) also should be adequate for this purpose. The blood group substances and the galactosamine sample initially were hydrolysed for 2 hr. in 2 *N* hydrochloric acid in a boiling-water bath

precision of the method apparently is the reproducibility of the Blix test. As a matter of routine, total hexosamines are determined in triplicate, and two aliquots of each sample are incubated with yeast and analysed in duplicate. 2–4 μmoles of total hexosamine (0·43–0·86 mgm. of the hydrochlorides) usually are sufficient for a complete analysis of each sample. This varies, of course, with the relative composition of the unknowns.

We wish to express our appreciation to Dr. Herbert J. Rapp for suggesting the use of a micro-organism for this separation. The work was supported by a Fight for Sight grant of the National Council to Combat Blindness, Inc., New York, and by grant *B*–141 of the National Institute of Neurological Diseases and Blindness, U.S. Public Health Service.

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Contact Angles and Work of Adhesion

Because of frequent misunderstandings, we would like to emphasize that the work of adhesion W_{SL} in the equation,

$$W_{SL} = \gamma_L(1 + \cos\theta) \qquad (1)$$

which one of us has recently pleaded[1] should be called Young's equation, is the reversible work required, per square centimetre, to separate the liquid from the solid, leaving an adsorbed film in equilibrium with the saturated vapour of the liquid on the surface of the solid. This work is less than the work W_{SLO} required to separate the liquid from the solid, leaving a clean surface free from adsorbed vapour, by π_{SV^0}, the surface pressure of the adsorbed film of vapour on the solid. Calling W_{SL} in (1), W_{SLV^0}, to indicate the presence of the adsorbed film of saturated vapour,

$$W_{SLO} = W_{SLV^0} + \pi_{SV^0} \qquad (2)$$

Harkins and Livingston's remark[2] that "it is extremely unfortunate that this equation came into notice at all" was made because Harkins had previously used W_{AB} for the work required to separate two liquids *A* and *B*, with clean surfaces and surface tensions undiminished by surface films of the other liquid. Later in the same paper[3] Harkins and Livingston stated that equation (1) is correct provided that W_{SL} means W_{SLV^0}, not W_{SLO}. The importance of the adsorbed film of vapour for the magnitude of the work of adhesion is usually greater for solid–liquid than for liquid–liquid systems; and attention has frequently been directed to it, first by Harkins and Dahlstrom[4], later by Bangham and Razouk[5], Harkins and Livingston[2], and by others.

π_{SV^0}, the difference between the work of adhesion to the clean and to the film-covered surface, cannot be measured directly; but π_{SV^0} can be calculated if the adsorption isotherm of the vapour on the solid can be measured. If Γ is the amount adsorbed when the pressure of the vapour of the liquid is p, the Gibbs adsorption equation,

$$\Gamma = \partial\pi/RT\partial\ln p \qquad (3)$$

can be integrated to

$$\pi_{SV^0} = RT\int_0^{p^0}\Gamma d\ln p \qquad (4)$$

as was shown by Bangham and Fakhoury[6], and Bangham[7]; p^0 is the saturated vapour pressure of the liquid.

W_{SLV^0} is probably the work of adhesion of greatest practical importance and is by far the easiest to measure, since the part of the solid surface of importance for determining the contact angle is that immediately adjacent to the edge of the liquid, and must therefore be in equilibrium with vapour which is saturated, or nearly saturated. If W_{SLO}, which may be of greater theoretical interest, is required, the amount Γ adsorbed at a series of pressures of the vapour of the liquid must be measured and equations (2) and (4) used. On surfaces smooth enough to permit easy measurement of the contact angle, however, Γ will be so small that its measurement will usually be difficult.

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A Sensitive Micro-Spectrophotometric Method for Succinate Analysis

ASSAY of succinic acid by estimation of reduction of a redox dye in a succinic dehydrogenase and cyanide – poisoned system has been reported by Lardy[1] for methylene blue, and by Vishniac and Ochoa[2] for 2,6-dichloroindophenol. The disadvantage to the use of these dyes is that they are non-enzymatically reoxidized directly by oxygen and there is uncertainty concerning the end-point of the reduction of the dye and thus about the amount of succinate oxidized.

In our experiments air was displaced with argon in the solutions used and in the ground-glass stoppered Beckman cells employed. The cells were charged in an argon atmosphere in an open-top rectangular jar.

A 20 per cent succinoxidase[3] suspension which was quite stable in ice for several hours was prepared with 0·1 *M* phosphate buffer (*p*H 7·4) and homogenized in ice (using a low-speed drill press) for 7 min. with a 'Teflon' pestle glass homogenizer. This homogenization time of 7 min. was found to be the best of many intervals tested in order that sedimentation effects of tissue particles in the Beckman cells be minimized.

Each Beckman cell, including the 'blank' cell, contained 0·1 ml. 20 per cent tissue suspension (0·67 per cent after dilution in cell), 0·3 ml. 0·1 *M* potassium phosphate buffer (*p*H 7·4), 0·1 ml. 0·05 *M* potassium cyanide, 0·5 ml. 0·01 per cent, 2,6-dichloroindophenol dihydrated sodium salt, and 1·8 ml. glass-distilled water. It was found that the 0·67 per cent tissue suspension used in the Beckman cell media was preferable to the 2 per cent suspension used by Umbreit[3] for manometric analyses, because of both optical considerations and difficulties incurred with reduction of the dye by endogenous substrate in the succinoxidase preparation. Beckman readings showed that the endogenous reactions went to completion in about 6 min. At this point a further addition of 0·2 ml. of water was made to the 'blank' cell, and 0·2 ml. of 5×10^{-4} *M* sodium succinate solution (or any unknown solution) was added to all other cells. The 'blank' cell was adjusted to a high enough scale reading so that negative readings need not be taken on the other cells.

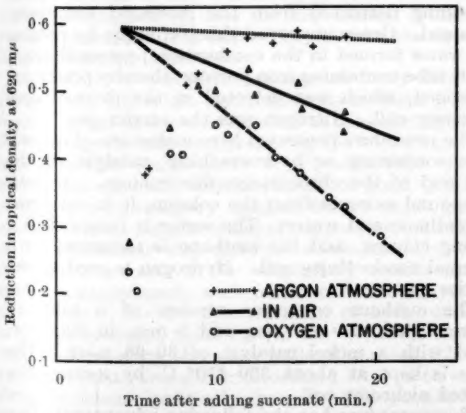

Fig. 1. Decreases in density relative to the 'blank' cell during the stated periods of incubation in systems varying from 0 to 100 per cent saturation with oxygen. The straight lines coming to a common point represent extrapolation of the slopes of the three curves

The relative effects of atmospheres of argon, air and oxygen on changes in optical density after addition of the stated amount of sodium succinate in each system are compared in Fig. 1. The Beckman density readings refer to relative decreases in density from the 'blank' cell. It is clear from these comparisons that by substituting argon for oxygen, reversal of the reduction of the dye through direct re-oxidation is avoided, and a more valid measurement of succinate content thus achieved. By extrapolating the slopes of the three curves in Fig. 1, and observing a common point of intersection, one again may see the desirability of working in the anaerobic system described in order to achieve maximum effects. The sensitivity of the argon system is such that each 0·01 Beckman density unit is proportional to 0·00167 μmole of succinate. Accuracy to the nearest 0·01 μmole of succinate may thus be achieved.

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Formation of Carbon by Decomposition of Carbon Suboxide at 750-780° C.

THE recent communication by Deitz and Prosen[1], which suggests that carbon suboxide is the means of transport of carbon in the system carbon monoxide–graphite at 450° C., prompts us to record some observations on the decomposition of carbon suboxide.

During attempts to prepare carbon suboxide by the pyrolysis of diacetyl tartaric anhydride[2] at 750–780° C., the formation of lustrous flakes was observed in the hot part of the reactor. This material was probably formed by polymerization of carbon suboxide, followed by decomposition of the polymer[3].

These lustrous flakes (0·5 per cent w/w of the diacetyl tartaric anhydride initially present) were shown by chemical and spectrochemical analyses to be essentially carbon, with about 1 per cent of hydrogen and of oxygen; trace impurities (silicon, aluminium, iron and magnesium) were present. A Debye–Scherrer X-ray diffractogram showed a strong 002 band and weak 100 and 110 bands. The optical reflectance measured in cedar wood oil was 18 per cent, a value higher than that (about 11 per cent[4]) reported for natural graphite.

It is noteworthy that instead of a soot, a hard graphite-like material was deposited at these low temperatures.

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Wave-length Effect in Flash Photolysis

When oxygen-free solutions of methylene blue or thionine in dilute sulphuric acid are subjected to flash photolysis using orange-red light filtered from a krypton- or xenon-filled flash-tube, reversible bleaching of the dyestuffs occurs. The bleaching is accompanied by increased absorption in the region 360–440 mμ where the dyestuffs themselves absorb very weakly. The transient species responsible for this absorption have the appearance of being triplet levels of the dyestuffs, disappearing with life-times of less than 30 μsec. The same species are also produced when the light of the flash is filtered through Chance *OX7* glass (transmission approximately 250–390 mμ).

When the unfiltered light from the flash-tube is used for excitation, there are formed, in addition to the 'triplet' species, other species which disappear much more slowly (half-life of the order 0·5 msec. under the conditions of experiment). From the limited information at present available, the second type of species appears to be similar to the semiquinones which are formed by reduction of the dyestuffs when their solutions are flashed with orange-red light in the presence of 0·1 *M* ferrous sulphate (in the presence of the ferrous sulphate the 'triplet' species are no longer evident). If the long-lived species are indeed the semiquinones of the dyestuffs, it would appear that water itself can act as the reducing agent when short wave-length ultra-violet light is used for excitation.

Whatever the true nature of the long-lived and the short-lived species, they are formed by independent processes, the long-lived species by wave-lengths shorter than 250 mμ and the short-lived species by longer wave-lengths. These observations may be compared with the results obtained by Bridge and Porter[1] in the flash photolysis of solutions of duroquinone using the full light of the flash-tube. They observed the independent formation of both triplet and semiquinone radical, and it is interesting to speculate whether their results can be explained in terms of a similar wave-length effect, since many of the solvents they used are transparent to wave-lengths shorter than 250 mμ. Before the behaviour of duroquinone can be fully established, therefore, it would be necessary to carry out experiments with filtered exciting light. This same precaution naturally applies to all flash-photolysis work, and is of course particularly important in those investigations where photosensitization to daylight is in question.

The investigation of the effects observed with methylene blue and thionine is being continued and will be reported in detail elsewhere.

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[1] Bridge, N. K., and Porter, G., *Proc. Roy. Soc.*, A, **244**, 259, 276 (1958).

The fact that primary photochemical processes may depend on wave-length is, of course, well known, and investigations of wave-length effects in flash photolysis have previously been carried out[1]. Our work on duroquinone was concerned with the identification of the intermediates and of the kinetics of their reactions, which are, for any given intermediate, independent of wave-length.

A study of the effect of wave-length on the primary products of photolysis of duroquinone is now in progress. Mr. Michael Reed has found that when a glass filter (cut-off at 300 mμ) is used, triplet-state absorption in liquid paraffin and formation of semiquinone radicals in ethanol are still observed, though the concentration of radical is considerably reduced. Some reduction in concentration is to be expected on the basis of reduced light absorption, since the maxima of duroquinone lie at 270 mμ ($\log\varepsilon = 4{\cdot}3$), 340 mμ ($\log\varepsilon = 2{\cdot}3$) and 450 mμ ($\log\varepsilon = 1{\cdot}4$).

If Parker's assignments are confirmed, the methylene blue system provides another example where radical formation does not occur principally via the triplet state. So far as dependence on wave-length is concerned, it will be necessary to have observations on the quantity of light absorbed in each experiment and the effect of intensity, since both wave-lengths and intensity have been varied and the observed differences may be attributed to either.

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[1] Christie, M. I., Harrison, A. J., Norrish, R. G. W., and Porter, G., *Proc. Roy. Soc.*, A, **231**, 446 (1955).

A Methane-Conversion Detector for Gas Chromatography

Detectors most commonly found in gas chromatographic instruments involve the use of thermal conductivity cells. Such cells, particularly those of the thermistor type, decrease in sensitivity with increasing temperature. Since it is necessary sometimes to heat the cell to prevent condensation effects of high-boiling materials leaving the chromatographic column, new approaches to this problem were sought. Martin and Smart[1] were successful in improving the sensitivity by converting the resolved compounds as they emerged from the chromatographic column into carbon dioxide and water, and detecting the carbon dioxide by means of an infra-red gas analyser. This procedure was repeated by Green[2] using a thermal conductivity cell to measure the carbon dioxide; however, loss of resolution and band spreading detracted from the increased sensitivity obtained. Green improved this technique by passing the water formed in the combustion process through a hot tube containing iron powder, thereby producing hydrogen, which was detected in the thermal conductivity cell. Nitrogen was the carrier gas.

The procedure presented here makes use of a small tube containing a 'hydrocracking' catalyst at the exit end of the chromatographic column. As each compound emerges from the column, it is converted to methane and water. The water is removed in a drying column, and the methane is measured by a thermal conductivity cell. Hydrogen is used as the carrier gas.

The methane converter consists of a tube of 'Pyrex' glass, 24 cm. long and 5 mm. in diameter, filled with a nickel catalyst of 30–60 mesh. The tube is kept at about 350–450° C. by means of a heated nichrome coil.

This procedure has the following advantages:

(1) Increased sensitivity is obtained by being able to operate the thermal conductivity cell at ambient temperatures, since only methane is being detected.

(2) Calibrations due to differences in thermal conductivities of the separated components are unnecessary; however, the carbon number effect must be considered.

(3) The method is applicable to other detectors where hydrogen is used as a carrier gas, such as the hydrogen flame detector[3].

(4) It offers a convenient way of analysing aqueous solutions of aldehydes, alcohols and ketones, since these are easily converted to methane and water over the catalyst. The water may be removed by a suitable drying column containing, say, calcium sulphate.

Compounds susceptible of complete 'hydrocracking' to methane have been analysed using hydrogen as the carrier gas. The methane conversion procedure has been used for mixtures containing (*a*) C_1–C_{12} paraffins and olefins, (*b*) C_5–C_8 naphthenes, and (*c*) C_2–C_5 aldehydes, alcohols and ketones. The catalyst remained active for more than 100 samples.

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May 5.

[1] Martin, A. E., and Smart, J., *Nature*, **175**, 422 (1955).
[2] Green, G. E., *Nature*, **180**, 295 (1957).
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Contamination of Surfaces by Conductivity Water from Ion-exchange Resins

IN several recent papers research workers in surface chemistry have reported using ion-exchange resins as a convenient means of removing electrolytes—in place of dialysis in the treatment of inorganic sols, for example, and to obtain 'conductivity water' for studies of dilute detergent solutions or monolayers on a Langmuir trough. For most purposes where 'pure' water is needed, even in colloid chemistry, the water obtained by passing ordinary distilled water through a 'mixed-bed' ion-exchange resin column is perfectly satisfactory, but for any critical work in surface chemistry it is not. The dangers are shown by the following experience.

In a study of the surface charge on finely divided particles by the micro-electrophoresis method, water from a mixed-bed resin column was used throughout for washing the cell and preparing the solutions. It had a specific conductivity of 0·3 micromho cm.$^{-1}$ and would normally be considered of good quality compared with ordinary distilled water, which gives about 3·5 and contains traces of copper, etc. A series of determinations with different dilute salt solutions gave what seemed to be satisfactory results until similar measurements were made with dilute hydrochloric acid. As the concentration of hydrochloric acid was increased from 10^{-6} to 10^{-4} *N*, the electro-osmotic flow along the glass walls of the cell fell to zero and then reversed in direction; that is to say, the glass became positively charged. (The suspended particles on the contrary remained negatively charged.) The anomalous charge on the glass was eventually ascribed to contamination by traces of a weakly basic substance from the resin column—almost certainly soluble polymer fragments released from the nitrogenous anion-exchange resin.

The presence of traces of organic impurities in water from resin columns is very difficult to check by direct analysis, but it is well known that water which has stood for some hours in a mixed-bed shows a relatively high conductivity. (Several 'bed-volumes' must first be run off to waste.) Clearly, this cannot be due to micromolecular electrolytes since these are effectively removed by the resins. It must be caused by colloidal polyelectrolytes, released by the resins and unable to penetrate into the resin particles of opposite charge because of size.

The purity of water from a mixed-bed column is therefore dependent on the time of contact with the resin. Rapid flow through a short column may allow electrolytes present in the feed water to 'break through', but slow flow through a long column may introduce organic polyelectrolytes.

Conductivities as low as 0·065 micromho cm.$^{-1}$ at 25° C. have been reported[1] for water from a mixed resin bed in favourable circumstances, and this is remarkably close to the theoretical value of 0·055 at 25° C. for perfectly pure water; but it is common experience to find values in the range 0·1–0·5 micromho cm.$^{-1}$. This conductivity value is a dangerous index. It can easily be dismissed as due to an 'insignificant trace' of electrolyte (for example, 10^{-6} *N* potassium chloride), but in fact may indicate a considerably higher (though quite unknown) amount of surface-active polyelectrolytes which may accumulate by adsorption on suitable surfaces.

With improvements in the stability of ion-exchange resins and careful attention to flow conditions, it may become possible to reduce the danger to almost negligible levels. But at the present time it is clearly advisable to avoid the use of resins entirely in all critical work in surface chemistry where small surface areas are concerned. Repetition of the experiments mentioned above, but using triple-distilled water finally condensed in silica, gave significantly different results for the suspended particles as well as for the glass surfaces.

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Void Nucleation Sites in Creep of Metals

FOR metals undergoing slow deformation at elevated temperatures, it has been shown that nucleation of voids by condensation of lattice vacancies requires either a very high concentration of excess vacancies (approximately 100 times the equilibrium value[1]), or very high concentration of stress[2]. It appears that such concentrations of vacancies are never approached even at high rates of deformation[3], so that voids must form at points where sufficiently large stresses develop. It has been suggested that ledges on a sliding grain boundary may provide these sites for nucleation.

The nature of ledges in the boundary is uncertain. Gifkins[4] suggested that they result from slip in one grain on planes almost perpendicular to the boundary being accommodated by slip in the adjoining grain. He believed that this mechanism required a pile-up

of dislocations at the end of the slip plane. McLean[5] considered that the ledges are formed by glide of dislocations to the boundary. However, in these cases it might be expected that an increase in temperature or decrease in rate of strain (that is, increased duration of test) would facilitate such stress-relieving processes as movement of the ledge itself[5], or boundary migration, which would flatten out the ledges. Thus it appears that to form holes the ledges must be locked in position.

An alternative possibility is that the ledges causing formation of voids cannot be flattened out by migration due to their inherent structure. Thus suppose that a dislocation with a screw component normal to the plane of the boundary intersects the latter, then a step will be produced at the boundary similar to the steps observed in crystal growth. Such steps would inhibit sliding[5] and provide sites for the development of the high stress concentrations necessary for void nucleation. It may be possible for a number of nearby screw dislocations of the same sign to interact to form steps many atomic distances high. Dislocations of opposite sign emerging into the grain boundary near each other may combine to form terraces.

If the above mechanism of hole formation be correct, the ease of nucleation in a pure metal should be related to the size of the dislocation network, that is, to the number of sites available. In metals such as aluminium, which has non-extended dislocations, grain boundary steps might be annihilated by cross-slip of nearby dislocations to produce atomically flatter surfaces, as shown by Anderson and Dawson[6]. This would account for the absence of visible formation of voids in aluminium of very high purity fractured under creep conditions. In less pure metals or alloys, locking of the screw dislocations by impurities or by edge dislocations already anchored will be an important factor in causing formation of voids. The difficulty encountered in improving resistance to creep without adversely affecting ductility might also be due to the dislocations giving ledges at the boundary being anchored as a result of hardening within the grains.

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May 6.

[1] Seitz, F., *Acta Met.*, **1**, 355 (1953).
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Fracture Markings in Polymethyl Methacrylate

The surface markings on the fracture surfaces of glass and plastics show that the fracture is discontinuous and that patterns are formed through secondary initiations ahead of the main fracture front which unite to form the completed fracture surface[1-3]. Intersection of an isolated secondary fracture with the main crack front usually produces a parabolic marking[3,4]. Such centres of secondary initiation are microcracks, stress-raising discontinuities, or inclusions. New evidence has been obtained of the importance of such flaws in fracture behaviour and patterning in polymethyl methacrylate.

The tensile fractures of conventional test specimens of the material in cast and (dental) moulded form have been found to show striking differences. The fatigue fractures are likewise dissimilar. These differences are little affected by ambient conditions and have been ascribed to structural effects. The cast material, which was obtained commercially ('Perspex') and from syrup initiated by benzoyl peroxide, is macroscopically homogeneous, whereas the material moulded by dental techniques has a grain structure consisting of the original polymer particles, which are approximately spherical, embedded in a matrix of newly-formed polymer. This structure was clearly revealed by etching with 80–90 per cent nitric acid, which preferentially attacked the matrix material.

The tensile fracture (A.S.T.M. *D*638–52*T*) of the cast sheet ('Perspex'), both at 20–22° C. and 50–65 per cent relative humidity and at 37° C. and 100 per cent relative humidity, showed a typical cleavage appearance similar to that described by Kies[1] and George[3]. The smooth mirror-like surface had a number of parabolic markings (Fig. 1*a*). In contrast, the dental polymer showed a much more complex and discontinuous fracture (Fig. 1*b*). A small mirror-like origin was the centre of a number of rough concentric ridges made up of three-dimensional crack systems separated by smoother regions which themselves contained extreme complexity of markings. The fracture markings of cast sheet made from syrup (probably containing dust particles) were intermediate between these extremes, showing two or three ridges on a fairly smooth surface. Lowering the temperature and increasing the rate of loading caused the appearance of the fracture in cast sheet to approach that of the moulded material, but even at −60° C. the 'Perspex' fracture did not attain the complexity of the latter.

The long-term fatigue fractures (plane bending, 1–5 c./s., in room conditions, and at 37° C. and 100 per cent relative humidity) were different in morphology also. 'Perspex' showed a mirror-like origin and smooth surface, while the moulded polymer showed an area of origin containing propagation markings (Kies's "river systems") which gave place to a smoother surface on which the grain structure was delineated by many parabolic markings with heads concentrated at grain boundaries. The service

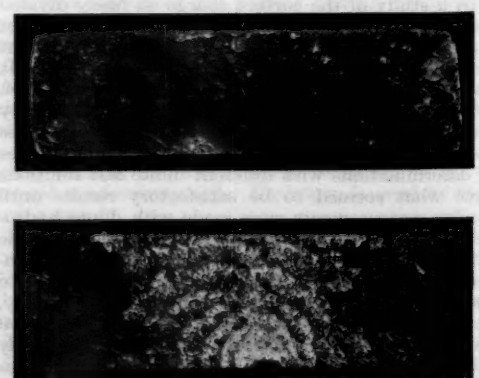

Fig. 1

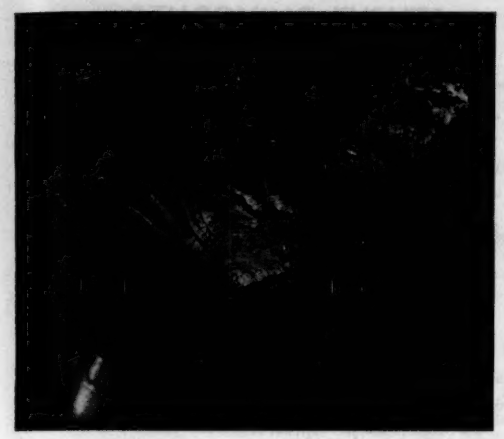

Fig. 2

fracture of polymethyl methacrylate upper dentures (Fig. 2) is similar, but shows the usual arrest markings.

The differences in tensile, and in fatigue, fracture can be explained in terms of the load magnitude, the flaw distribution, and their effect on crack propagation.

The tensile crack starts at some surface fault (occasionally internally) and rapidly increases in velocity as the stored elastic energy diminishes[3,5]. Where there are few major flaws as in 'Perspex', few secondary cracks are produced and these become enveloped quickly. Since the stress field contracts and crack velocity increases, however, the final fracture becomes complex[6]. In the moulded material the large number of major flaws results in the formation of multiple cracks at some critical velocity of the crack-front. The diminution in stored elastic energy results in a momentary hesitation while the energy builds up again, since more energy is required to start a crack than to propagate it[7]. Repetition of this cycle gives the regular discontinuous appearance.

In the case of fatigue failure, the initial cleavage fracture which occurs quite early in the test is propagated only slowly. Since the overload is small in the case of the moulded material, only the major flaws at grain boundaries act as nuclei.

This explanation is substantiated by the change in patterning which takes place if the cast polymethyl methacrylate is pigmented, when the tensile fracture becomes discontinuous as in Fig. 1*b*. A similar phenomenon has been observed in extruded polystyrene rod. Thus the mode of fracture in these materials is dependent on the number and distribution of flaws.

It is hoped that a fuller account of this work will be published elsewhere.

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April 21.

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Scintillation Counter for measuring Radioactivity of Vapours

The gas chromatographic technique of James and Martin[1,2] is often used to fractionate substances biosynthesized from precursors labelled with carbon-14. For the assay of carbon-14 in the various fractions it is necessary, at present, to collect the fractions individually and then transfer them to a counting device. Direct measurement of the radioactivity of vapours as they leave the chromatographic column would save much time and labour and improve accuracy.

We have devised an instrument which counts the carbon-14 content of vapours emerging from a gas chromatographic apparatus parallel with the analytical chromatographic record. In principle, the chromatographic vapours are condensed into a circulating liquid phosphor: a solution of diphenyl oxazole in xylene. The scintillations excited in the phosphor by the carbon-14 are detected with a photomultiplier.

Fig. 1 illustrates the instrument diagrammatically. The vapours and carrier gas (nitrogen) flow through capillary tube *A*, which is heated electrically to the temperature of the column; then they bubble into the liquid phosphor, which is kept in vigorous circulation around the circuit *BCDE* by the bubbles of carrier gas rising in tube *B–C*. As the vapours are soluble in xylene and have high boiling points they are stripped from the carrier gas on entering the liquid phosphor. Jacket *F* cools the xylene on its path from *A* to the counting cell *S*. This cell is a cylindrical cavity (1 cm. deep, 15 ml. capacity) formed by pressing a polyethylene cup over the window-end of a photomultiplier. Thus the scintillations produced in the phosphor are 'seen' directly by the photomultiplier, there being no loss of light due to interfaces between the phosphor and the photomultiplier.

The phosphor is introduced and removed through a thin polyethylene tube, inserted into opening *X*, and extending to point *E*. The opening *X* also allows the carrier gas to escape. A combined support and lead shield holds the photomultiplier horizontally, the whole assembly being placed in a lagged and light-tight box. Cooling liquid at about 0° C. is pumped through tubes in the side of the box and circulated through the jacket *F* and the photomultiplier support.

Pulses from the photomultiplier are amplified and fed into a rate-meter and recorder. The record of

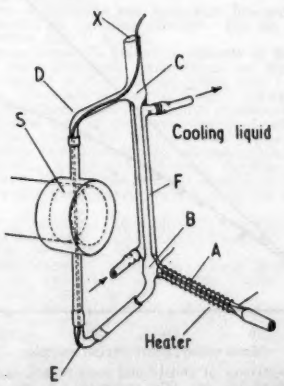

Fig. 1. Instrument for measuring radioactivity of vapours

radioactive counts is of integral form, identical in shape with the records of chromatograms obtained from the automatic titration instrument of James and Martin[1].

By injecting a known amount of fatty acid labelled with carbon-14 into the phosphor, the overall efficiency of counting was found to be approximately 30 per cent, which is satisfactory as the photomultiplier 'sees' only about two-thirds of the total volume of phosphor. The background count, including electronic noise, was 3·8 counts/sec.

A full description of the technique and constructional details of an improved apparatus will be published elsewhere.

We wish to thank Dr. G. Popják for suggesting the technique and for his advice and encouragement, and Messrs. E. K. Cole for the loan of the photomultiplier.

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Counting Error due to Overlapping Particles in Thermal Precipitator Samples

The thermal precipitator[1] is widely used as a standard instrument for sampling dust clouds. The dust from a measured volume of air is deposited on glass slides and is afterwards counted under a microscope.

Some particles consist of several smaller ones clumped together and these 'aggregates' are counted as single particles. Other particles are deposited so that they overlap ones already deposited, producing spurious aggregates. These cannot be distinguished from true aggregates and consequently the dust concentration is under-estimated. In the many previous tests of the thermal precipitator the magnitude of this error does not seem to have been investigated.

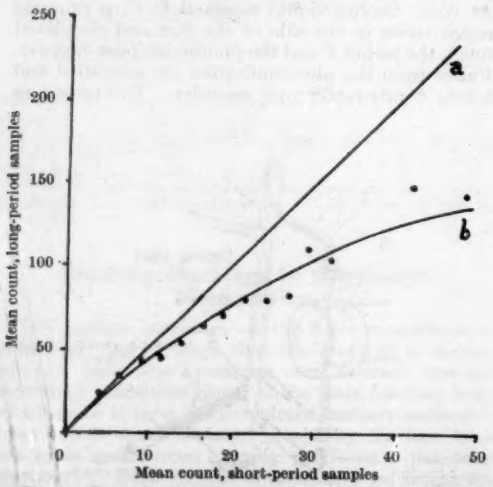

Fig. 1. Comparison of short- and long-period samples; total number of particles per 20μ traverse; *a*, no overlapping; *b*, fitted curve

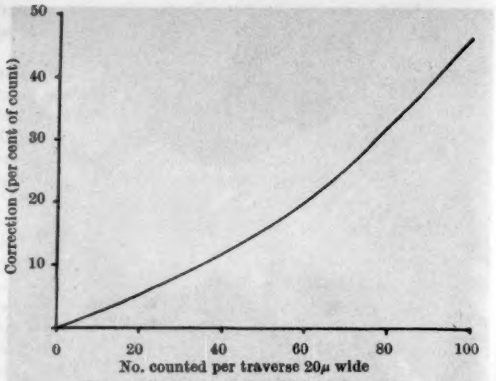

Fig. 2. Correction to be added to the count

Two thermal precipitators were placed in a colliery and pairs of samples were taken in which one of the instruments samples for five times as long as the other. A comparison of corresponding mean counts from the two instruments is given in Fig. 1. The short-period counts were grouped and the corresponding long-period means calculated. In the absence of overlapping the long-period counts would be five times the short-period counts, shown by the straight line. In fact they were less, by an amount which increased with the density of the deposit, indicating that a considerable amount of overlapping occurred in the denser samples.

The mean projected area of the particles was 18·6μ^2. With finer dusts the effect of overlapping will be smaller.

A curve was fitted to the results using an equation similar to those derived theoretically by other workers[2]. From this curve we can estimate the correction to be added to the number counted to make it equal to the number deposited (Fig. 2).

The results show that with sample densities of 25–50 particles per 20-μ traverse, the true dust concentrations of the coal dust cloud are between 5 and 15 per cent higher than those estimated from the counts. Other workers have recommended densities several times greater than this[1,3]. If such densities were in fact used, the overlap error would be very large. The error can be reduced by using very low densities, but the extraneous contamination then becomes an increasingly large error. Consequently it does not seem to be possible in practice to avoid the error introduced by overlapping particles when sampling airborne dust similar to that occurring in this coal mine. The value of the thermal precipitator as a standard reference instrument in coal mines is therefore open to doubt and needs re-investigation against an absolute standard such as a sedimentation cell.

A full report of this work will be published elsewhere.

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FORTHCOMING EVENTS

Wednesday, July 16

INTERNATIONAL PALÆONTOLOGICAL UNION (in Room 128, Royal School of Mines, Prince Consort Road, London, S.W.7), at 4 p.m.—General Meeting. (Second General Meeting on July 17.)

Friday, July 18

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, The University, Sheffield), at 2 p.m.—375th Meeting.

Saturday, July 19

BRITISH PSYCHOLOGICAL SOCIETY (at Birkbeck College, Malet Street, London, W.C.1), at 2.30 p.m.—Prof. E. N. Sokolow (University of Moscow): "Objective Study of Hearing Disorder".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER (with a first- or second-class honours degree and experience in lecturing in soil science and agricultural chemistry) IN SOIL SCIENCE AND AGRICULTURAL CHEMISTRY at Shambat Agricultural Institute, Education Division, Ministry of Agriculture, Sudan—The Sudan Embassy, Personnel Section, Cleveland Row, London, S.W.1, quoting Ref. "Lecturer Soil Science 4/447" (July 15).

SENIOR LECTURER or LECTURER (male, British, with a first- or second-class honours degree in mechanical engineering) IN THE APPLIED MECHANICS DEPARTMENT; and a SENIOR LECTURER or LECTURER (male, British, with an honours degree or equivalent in electrical engineering, and preferably special experience in telecommunications) IN THE PHYSICS AND ELECTRICAL ENGINEERING DEPARTMENT—The Director of Studies, R.N. College, Greenwich, London, S.E.10 (July 18).

AREA CHIEF SCIENTIST (with a good degree (or equivalent) in chemistry, physics or fuel technology and wide industrial experience) in the Cannock Chase Area—The Divisional Chief Staff Officer, West Midlands Divisional Coal Board, Himley Hall, Dudley, Worcs, quoting NA (July 19).

ASSISTANT, Grade B (preferably with experience in industry, teaching and/or research), IN INORGANIC CHEMISTRY—The Principal, Nottingham and District Technical College, Burton Street, Nottingham (July 19).

ASSISTANT LECTURER, Grade B (with professional qualifications in biology and preferably the ability to teach microbiology or bacteriology) IN BIOLOGY at the City College of Technology, Byrom Street, Liverpool—The Director of Education, City of Liverpool Education Committee, 14 Sir Thomas Street, Liverpool 1 (July 19).

ASSISTANT LECTURER IN THE DEPARTMENT OF NUMERICAL AUTOMATION, with special reference to electronic calculation and numerical analysis—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (July 19).

ASSISTANT ENGINEERS (with the H.N.C. or a degree, or other suitable technical qualifications in physics, applied physics and mathematics, or electronics, and preferably some practical experience) IN THE DESIGN SECTION of the Nuclear Power Plant Design Branch at Headquarters, London, to work on problems of radiation levels in relation to health physics—The Chief Personnel Officer, Central Electricity Generating Board, 24–30 Holborn, London, E.C.1, marking envelope "Confidential" and quoting Ref. N/173 (July 21).

ASSISTANT LECTURER IN THE DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY—The Dean, St. Thomas's Hospital Medical School, London, S.E.1 (July 25).

LECTURER (preferably with qualifications in mathematical statistics) IN STATISTICS—The Secretary, The University, Aberdeen (July 25).

LECTURER (with postgraduate research experience and preferably previous academic teaching experience) with special interests in Physical-Organic Chemistry—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (July 26).

REGIUS CHAIR OF BOTANY in the University of Edinburgh—The Private Secretary, Secretary of State for Scotland, St. Andrew's House, Edinburgh 1 (July 28).

RESEARCH ASSISTANTS (with, or expect shortly to possess, an honours degree in chemistry, or A.R.I.C.) IN ORGANIC AND ORGANO-METALLIC CHEMISTRY—The Registrar (Room 22, O.R.B.), The University, Reading (July 31).

ASSISTANT PROFESSOR OF METALLURGY—Head of the Department of Mining and Metallurgy, University of Alberta, Edmonton, Alberta, Canada (August 1).

LECTURER IN PHARMACOLOGY—The Registrar, Trinity College, Dublin (August 1).

LECTURER IN EDUCATION at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 4).

LECTURER (qualified in either mycology and plant pathology, or physiological or biometrical genetics) IN BOTANY; a LECTURER or SENIOR LECTURER IN FLUID DYNAMICS; and a LECTURER (preferably strong in applied mathematics or physics and interested in fundamental geophysics rather than geophysical prospecting) IN GEOPHYSICS at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 4).

PROFESSOR OF BOTANY, a PROFESSOR OF CHEMISTRY, a PROFESSOR OF GEOLOGY, a PROFESSOR OF PHYSICS, and a PROFESSOR OF ZOOLOGY—The Registrar, Canberra University College, Canberra City, Australia (August 8).

SENIOR LECTURER IN HISTOLOGY, and a LECTURER IN ANATOMY, at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 11).

PHYSICAL METALLURGIST or METAL PHYSICIST (Principal Scientific Officer) (with a first- or second-class honours degree in metallurgy or comparable qualification, and at least three years relevant post-graduate experience) with the Admiralty at Rosyth—Civil Service Commission, 30 Old Burlington Street, London, W.1, quoting S.4858/58 (August 12).

CHAIR OF GEOGRAPHY in the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 13).

LECTURER or SENIOR LECTURER IN MATHEMATICS at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 15).

ASSISTANT BIOCHEMIST (young graduate with a good honours degree in chemistry or equivalent qualification, and preferably with analytical experience) IN THE DEPARTMENT OF PATHOLOGY, for duties which include participation in research, particularly in the field of steroids—The Group Secretary, Queen Elizabeth Hospital for Children, Hackney Road, London, E.2.

BIOCHEMIST (medical qualification not essential), to conduct research in the field of rheumatic diseases—The Director, Rheumatic Unit, Northern General Hospital, Ferry Road, Edinburgh 5.

JOSEPH LUCAS FELLOW, for research in the field of Electrometallurgy, with emphasis on the growth, structure and mechanical properties of electrodeposits—The Registrar, The University, Edgbaston, Birmingham 15.

METALLURGIST, CHEMIST or PHYSICIST (graduate, preferably with language knowledge) IN THE INFORMATION DEPARTMENT, for work on all aspects of recording and transmission of information on extraction, fabrication and use of non-ferrous metals—The Secretary, British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.

SCIENTIFIC OFFICER (with a good science degree, a reading knowledge of two European languages (preferably other than French or German), the ability to write good English and preferably a knowledge of soil science and plant physiology), for work in a scientific information service involving abstracting and indexing—The Director, Rothamsted Experimental Station (Commonwealth Bureau of Soils), Harpenden, Herts.

TECHNICIAN (with H.N.C. or equivalent in chemistry and/or physics, and preferably skill in laboratory techniques, for example, glass-blowing or electronics), to carry out experimental work and assist in the construction and maintenance of apparatus in the Department of Chemical Microbiology—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 58/5.

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